Terminal Transitions:
An Analysis of Projectile Points from the Terminal Middle Period on the Northern Plains

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To Kevin and Karena, whose passion for the outdoors inspired me

Abstract

The Terminal Middle Period (3000 to 2000 B.P.) and the Transitional Late Period (2000 B.P. to 1500 B.P.) contain a number of diverse projectile point styles belonging to several cultural complexes. The cultural complexes studied here include: Pelican Lake, Besant, Outlook, Bracken, Sonota and Sandy Creek. The point styles associated with these complexes have been in the past separated on largely visual or subjective bases. Clarifying the projectile point morphologies during this period will allow for better interpretations of archaeological sites on the Northern Plains. To aid in this clarification, twelve projectile point assemblages from nine previously excavated sites on the Saskatchewan and Alberta Plains were studied. These assemblages were subjected to geometric morphometric and discriminate function analysis. Beyond these two avenues of analysis, the assemblages were also subjected to metric testing to determine if the point styles were more consistent with arrow or dart projectiles. During this time period, the technological transition from the atlatl and dart to bow and arrow appears to have occurred. As a result of the arrow/dart testing, a pattern of robustness was seen in the kill site assemblages as compared to the habitation site assemblages. This resulted in larger points being found in communal kill sites in the study suggesting a link between game size and hunting methods. The result from this analysis recommends a reduction in the independent point styles suggested by other researchers. The data trends towards the finding that two major cultural complexes existed in the Terminal Middle / Transitional Late periods in the studied region of Northern Plains, Pelican Lake and Besant. A third minor group morphologicaly between the two major groups.

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Chapter 1
Introduction

This thesis explores the morphological variation present in one of the most easily recognized artifacts in the archaeological record, the projectile point. There is an obvious over representation of these artifacts in collections. This is particularly true on the Plains where there are few farmers who do not have a small box or bucket overflowing with these artifacts collected while breaking and working the land. Since becoming aware of these collections, archaeologists have wrestled with the problem of which point styles are representative of what time periods in the archaeological record.

In this work, a selection of Middle Period sites that straddle the line with the Late Period have been analyzed. The Middle Period (7500 to 2000 B.P.), especially the Terminal Middle Period (3000 to 2000 B.P.) and how it advances into the Transitional Late Period (2000 B.P. to 1500 B.P.), is a poorly understood portion of the cultural chronology on the Northern Plains. The projectile point morphologies from the Terminal Middle / Transitional Late boundary are very diverse. From this time period previous authors (Dyck 1983; Dyck and Morlan 1995; Kehoe 1974; Peck 2011; Wettlaufer 1955) have identified numerous different projectile point styles belonging to three, possibly four, cultural complexes and phases. As projectile point styles or varieties serve as one of the few temporally discrete artifacts from this period on the Northern Plains, they are heavily relied on to formulate the culture histories.

Whether these point styles constitute real individual styles or whether the division is subjective is one of the research goals of this analysis. This thesis seeks to shed light on the projectile point morphologies during this period through the use of geometric morphometrics and associated discriminate function analysis. Morphometrics is a branch of mathematical shape theory that is a quantitative way of addressing shape comparisons (Zelditch et al 2004:1). These comparisons use a highly abstract language that is often difficult to visualize. Geometric morphometrics (GMM) serves as a simplified way to disseminate and visualize the abstracted.

During this time period the technological transition from the atlatl and dart to bow and arrow is believed to have occurred. This adaptation may be responsible for the multitude of projectile point styles visible in the archaeological record as older styles of points were mated to newer smaller shaft technology. Metric testing was conducted on the assemblages to sort out whether the associated projectiles were the tips of darts or arrows. Statistical equations outlined by Thomas (1978), Knight and Keyser (1983), Bradbury (1997), Shott (1997) and Hildebrandt and King (2012) were all tested against a control group to determine a proper equation to use on the Northern Plains.

1.1 Research Objectives

The purpose of this thesis is to perform projectile point analysis of a select number of Terminal Middle/ Transitional Late Period Sites, with the intention of answering three specific research aims;

Firstly, *is the point classification used on the Canadian Plains supported by geometric morphometric testing?*

Secondly, *can the projectile points associated with these assemblages be assigned metrically to a known typology, and if not, where do they fit within the Plains point chronology?*

Thirdly, *do these projectile points represent a regional adaptation to the bow and arrow and is this responsible for the projectile point variation seen during this period?*

It is the hope of this study, beyond attempting to answer these questions, to show the benefits of a GMM approach to solving other typological issues in archaeology. This approach may eliminate some of the subjectivity in similar studies allowing for simplicity in cross regional, or interprovincial/national studies.

1.2 Chapter Outlines

This thesis is divided into seven chapters, and seven appendices. Chapter 1, provides an introduction and outlines the research objectives. Chapter 2 is an overview of the Plains culture history based on projectile point morphology as it pertains to this thesis with a focus on the Terminal Middle Period and the Transitional Late Period. The various point styles that will be studied are described with a brief introduction to the cultural complexes to which they belong.

Chapter 3 establishes the methodology used in this thesis. This chapter also highlights some of the various methods employed in previous research that sought to separate projectile point varieties. Contained in the latter half of this chapter is a brief introduction of GMM and Discriminate Function Analysis (DFA). The results of the arrow versus dart equation testing against a control group are presented here as well. The testing of the equations was undertaken as the majority of the equations were not designed for the Northern Plains and showed wide range accuracy when tested against known Plains projectile points.

Chapter 4 introduces the various sites and assemblages used in this thesis. Over the course of this study twelve assemblages and composite groups were analyzed from nine archaeological sites: Mortlach (EcNl-1), Long Creek (DgMr-1), Walter Felt (EcMn-8), Sjovold (EiNs-4), Crane (DiMv-93), Rocky Island (FaNp-7), Smyth (DjPm-116), Fitzgerald (ElNp-8), and Fincastle (DlOx-5). Each of these sites represents Terminal Middle or Transitional Late Period occupation of the Northern Plains.

Chapters 5 and 6 contain the results of this study and interpretations. Frequent reference is made to the appendices in these chapters due to the highly graphical nature of the GMM approach. In chapter 5, the results of the CVA, DFA, cluster analysis and arrow/dart metric testing are introduced with some attention paid to the trends presented by them. Chapter 6 is comprised of the interpretations of the results and elaborations of the trends. Each of the assemblages introduced in the chapter 4 will be placed within an associated phase/complex based on the results. In the latter half of this chapter an effort is made to sort out a modified culture history based on the connections and groupings brought forth by this analysis.

Finally, chapter 7 will conclude and summarize the adventure you have undertaken while reading this thesis. The appendices deal with the voluminous amount of graphical and tabular data created through the geometric morphometrics and metric testing analyses carried out on the aforementioned assemblages. Appendix A is the results of the CVA on the assemblages and contains the graphs and tables associated with this process. Appendix B contains the results of the DFA on the same assemblages, again with the many tables and figures that were created by this process. Appendix C is the results of the UPGAMA (Unweighted Pair Group Method with Arithmetic Mean) cluster analysis on the assemblages; in this appendix is not just the single diagrammatic representation but figures showing the change at each interval along the spidering cladogram. Appendix D contains the results of the metric testing for arrows and atlatl within the studied assemblages. Appendix E is the results of CVA, DFA, and metric testing on a reconfigured culture history based on the results of this analysis. Appendix F, G, and H are reference appendices. Appendix F contains the expanded results of the arrow versus dart equations testing against the control groups. To aid in further research on the assemblages studied here the artifact catalogue of the projectile points used in the analysis is contained in Appendix G, with some metric and nonmetric attributes listed. Appendix H includes pictures and some tables of attributes of the Walter Felt assemblages' level 10 through 15d, as they are often referenced but the quality of the existing images is lacking.

Chapter 2
Overview of Culture History Based on Projectile Point Morphology

The division of the archaeological record into manageable periods is routinely done by all archaeologists. These divisions better utilize the data but are done with the realization that the resulting time periods are primarily constructs of the archaeological community. Out of the many previous divisional schemes created for the Great Plains, I intend to use a modified version of the Cultural Chronology proposed by Cyr (2006:16-17), which is adapted from the one proposed and used by Walker (1992). This will segment the cultural chronology of the Plains into four time periods; the Early (Paleoindian) (12,000-7500 B.P.), the Middle (7500-2000 B.P.) which comprised three sub periods (Early Middle [7500-5000 B.P.], Mid Middle [5000-3000 B.P.], and Terminal Middle [3000-2000 B.P.]), the Late (2000-200 B.P.) which is comprised of two sub periods (Transitional Late [2000-1500 B.P.] and the Late [1500-200 B.P.]), and the Historic (200 B.P. -Present) periods. Only the two periods pertaining to the Terminal Middle Period/ Late Period Transition while be covered in the following chapters. The term "B.P." is used to refer to years before present (1950) when explaining the time breadth of complexes, phases or series. The terms phase, complex, series, component, and assemblage are used in this chapter and beyond to define cultural entities on the Northern Plains. A phase is defined by Willey and Phillips (2001:22 [1958]), and reiterated later by Reeves (1983:39), and Peck (2011:22) as an archaeological unit possessing traits sufficiently characteristic to distinguish it from all other units. It is not limited to a locality or region and can change through time, it should also show a discernible relationship between serial assemblages (Peck 2011:22, Reeves 1983:39, Willey and Phillips 2001:22 [1958]). If an assemblage does not show this relationship, it is then it is referred to as a complex (Peck 2011:22).A complex is an over arching term and is defined by Dyck (1983:69) as:

> a large composite archaeological unit. It consists of interconnected sites, features, and artifacts, tied together by similarities in function, style, technology, and subsistence-settlement system. [Complexes] are found within a common geographical distribution and within a common segment of time.

A series as, it is defined by Dyck (1983:69) as follows:

> a sequence of archaeological components sharing a common geographical space (sometimes within a single site, sometimes within a

region), but belonging within separate segments of time. A series is a crude unit of archaeological analysis used for convenience before sites, features, and artifacts are ready for reclassification into complexes and traditions.

On the smaller scale, McKern (1939:308) defines a component is as "any given focus (phase/complex) at a specific site" (McKern 1939:308) that is limited temporally. Multiple occupations at a site may either represent a single component or multiple components; they usually represent only a single occupation at the site (Willey and Phillips 2001:21-22). The term assemblage refers to the cultural material recovered from a component either within a site or within a larger complex or phase.

2.1 The Terminal Middle Period

The Terminal Middle Period is characterized by the Pelican Lake complex (3300 to 1850 B.P.). The projectile points belonging to this complex are identified as barbed corner-notched dart points with either straight or convex bases. Pelican Lake points vary greatly in size and some of the smaller examples may indicate an early adoption of the bow and arrow. Since first being identified at the Mortlach Site (EcNl-1) in south-central Saskatchewan (Wettlaufer 1955), these projectile points have turned out to be a very widespread and have been found at numerous habitation, tipi ring, bison pound, bison jump, and burial sites (Dyck 1983:105). Some of the earliest examples of Northern Plains pound sites are attributed to the Pelican Lake complex and may be a result of expanding bison and human populations on the plains (Foor 1982:111&166). Some authors divide the Pelican Lake complex into several phases (Dyck 1983; Kehoe 1974; Reeves 1983; Peck 2011) on the basis of variations in projectile point styles and also the appearance of communal hunting sites.

The origin of the Pelican Lake complex is an intricate matter as the corner-notched projectile point is quite wide spread during this time period. A development out of the earlier McKean series has been suggested (Reeves 1983). However, the McKean series had several cultural attributes that distinguished it from Pelican Lake. Structure type, (Peck 2011:237) burial practises, trade relations (Hoppa et al 2005:255-257, Walker 1982), subsistence strategy (refocusing on bison), and projectile point forms all suggest a different origin than the McKean series. Foor (1982) tries to locate the origins of Pelican Lake by looking at corner-notched projectile points. Several areas such as the Interior Plateau and the Great Basin have corner-notched projectile points that are contemporaneous to the Pelican Lake points on the Plains. The contemporary groups from the Great Basin and the Northwestern Plains also share other similar artifacts related to plant processing such as milling stones. This suggests some cultural continuity or interaction between the Northwestern Plains of Wyoming and the Great Basin (Foor 1982:175). However, Foor (1982:179-182) suggests that an Eastern Woodlands origin for Pelican Lake is more likely as some of the earliest archaic corner-notched projectile points are from the Eastern Woodlands. This would also follow the trend of later Plains complexes having various degrees of interaction and influence with the Eastern Woodlands. Authors such as Reeves (1983) and Duke (1985) suggest a stronger montane or western influence than an Eastern one drawing on the wealth of associated sites in the Crowsnest Pass of Alberta and intermontane regions of British Columbia. Reeves (1983) based this connection on lithic utilization from local sources, such as those from the Rockies which were utilized more often than those sources further east. The Pelican Lake Complex is seen as largely aceramic. One of the few examples of Early Woodland pottery associated with Pelican Lake points is found at the Naze Site (32SN246) in North Dakota. The pottery bearing occupation at this site dates from 2388±44 to 2472±45 (SMU-1759 & SMU-1761) and was contained three (3) Pelican Lake projectile points (Gregg 1987, Gregg and Picha 1989). Within the Pelican Lake complex, a great range of variation in the projectile point forms and lithic utilization exists.

One of the first to look at projectile point variation in Pelican Lake assemblages was Thomas Kehoe (1974). Using assemblages from several sites, Kehoe proposed several stylistic typologies for Pelican Lake projectile points. These included corner-notched barbed varieties such as the large and small Pelican Lake Classic and Hudson Barbed; a corner-notched eared variety, Sandy Creek (to be discussed later), and corner-notched stemmed varieties such as Bracken and Danker (Kehoe1974:104;109-111). Dyck (1983:105) simplified Kehoe's earlier work and suggested that two major varieties of Pelican Lake projectile points existed. The first and oldest was a narrow, straight based corner-notched variety with sharp tangs, which changed over time to one with a wider base. Dyck's (1983:105) second variety was similar to the first but appears around the half way mark of the Pelican Lake Complex's time span and is similar to the first variety but has a convex base. Peck (2011) formally splits the Pelican Lake complex into two parts, the earlier Pelican Lake and the later Bracken Phase, when referring to the Late

Pelican Lake assemblages. This was based on radiometric dates largely from sites in Alberta where a time frame for Early Pelican Lake seems to group around 3600 to 2800 B.P. and Late Pelican Lake (Bracken Phase) dates from 2800 to 2200 B.P. (Peck 2011:280).

A change in bison procurement strategies is suggested by both Kehoe (1974:103-104) and Peck (2011:281) between earlier and later Pelican Lake assemblages possibly supporting a division of the two phases. This change is twofold, involving an apparent change in bison procurement strategies and in projectile point styles which are linked. The change in bison procurement strategy displayed an increased utilization of large scale communal bison hunting employing pounds and jumps (Peck 2011:276; Kehoe 1974:104). This change is not only seen in the archaeological record by the usage of aforementioned communal hunting sites, but can also be seen in the stylistic changes of the projectile points. Both Peck (2011:281) and Kehoe (1974:103-104) see change from a corner-notched barbed point to a corner-notched shouldered point as an important change. This change would reduce the amount that the point and shaft would be retained in a wounded animal. The retention of the shaft hypothetically would not be needed if the animal was confined in a pound as follow-up shots would be far likelier than in a solitary stalking form of hunting where the increased damage resulting from the retained shafts impact on underbrush while the wounded prey fled, would allow for single projectiles to more easily down larger prey. This result could be better obtained if the dart was retained within the wound (Kehoe 1974:103-104). With the Pelican Lake Complex, particularly in the later portion, communal hunting appears to be quite wide spread with evidence of it at sites such as the Old Woman's Buffalo Jump and Head-Smashed-In in Alberta (Dyck 1983:107&108).

Contemporaneous with or immediately following the Pelican Lake culture, two lesser known cultures exist; an unnamed complex that dated to around 2500 B.P. and the Sandy Creek complex (2450 to 1950 B.P.) (Dyck 1983:107-109). The Sandy Creek complex was first identified at the Mortlach Site (Wettlaufer 1955). Two other side-notched styles of points also seem to date to this period other than the Sandy Creek point style. The first has straight to very slightly concave bases with narrow notches and have been called Outlook points (Dyck and Morlan 1995:437). The second variety, called Bratton points, exhibit a strongly convex base (Dyck and Morlan 1995:377). The all three styles have been found at the Sjovold Site (EiNs-4).

Starting during this time period (2500 B.P.) and into the Transitional Late Period, the climate is described as being wetter than preceding period (Bryson Wendland 1967:295-296). This increase in moisture would have resulted in a boost in grassland production and therefore swelling bison herds and in turn result in an increase in kill sites. The projectile point typological florescence during this period may be a result of increased local or migrant populations preying on the increased bison herds.

The Sandy Creek complex, first recognized at the Mortlach Site, includes a medium-sized side-notched, basally concave projectile point similar to earlier Oxbow points (Dyck 1983:108-109). At the Mortlach Site, the Sandy Creek level was above the Pelican Lake level and below the Besant levels. At the Walter Felt Site, the Sandy Creek component was between the Early Pelican Lake (Classic Variety) and Late Pelican Lake (Danker Variety, Bracken Phase) components (Wettlaufer 1955:50; Kehoe 1974:111). At the Sjovold Site, the Sandy Creek level overlays the Outlook level and is under a possible mixed Besant/Pelican Lake Level (Dyck and Morlan 1995).

Not much is known about Sandy Creek or the other unnamed complexes as few sites have been found that have been attributed to them. Some possible evidence for communal hunting associated with these types exists in Alberta (Peck 2011:254). Dyck and Morlan (1995) suggested that these lesser known complexes may be a part of the Besant Complex with Sandy Creek, Bratton and Outlook being early forerunners of the complex. This is supported by the appearance of these projectile points in other Besant assemblages (Dyck and Morlan 1995:378-379,398 & 435-437) and high quantities of Knife River Flint in the levels associated with these projectile points in the Sjovold Site (Dyck and Morlan 1995:399&438) as opposed to Pelican Lake peoples who showed an affinity to more local lithics (Dyck 1983:106).

Peck (2011:255 & 275) suggests that the Bratton and Sandy Creek points may fall within the variation of projectile points in what he calls the Bracken Phase. Another hypothesis regarding the later northern expressions of Oxbow may be the origin of Sandy Creek if the dates are to be trusted (Gibson 1981). If Pelican Lake is seen as an intrusive culture, the divergence of projectile points associated with Late Pelican Lake, and intrusions of early Besant groups (Outlook); may serve as evidence of a collective weakening in the Pelican Lake culture. If the early Pelican Lake cultural grouping lost its ability to maintain an exclusive occupation of the

Plains, it would allow southern groups and smaller regional groups to move into portions of the Northern Plains, producing new point styles and other cultural manifestations.

Outlook occupations are believed to represent early Middle Missouri/Plains Woodland ventures on to the Plains (Peck 2011:249). This is supported by the majority of Outlook sites being kill sites, the presence of bone uprights, and preference for Knife River Flint as a lithic material, which are all features of the later Besant/ Sonota Complexes (Peck 2011:249; Dyck and Morlan 1995:438; Varsakis 2006:100-107).

The exact relationship of these lesser known point styles to other complexes (Besant, Pelican Lake, etc.) is not well understood. With regard to Bratton, Sandy Creek, and Outlook, Dyck and Morlan (1995) have suggested that they are early examples of Besant projectile points, based on their findings at the Sjovold Site. They have suggested that the terms Outlook (straight based), Sandy Creek (concave based), and Bratton (convex based), be used to describe Besant points respectively throughout the Besant complex. They also suggest that "Besant" be dropped as a point style name and that the name Besant only be used to describe the series (Dyck and Morlan 1995:398&437). Alternatively they may be local cultural manifestations unrelated to the later Besant groups.

2.2 Transitional Late Period

The Transitional Late Period is represented across the Northern Plains by the appearance of the Besant complex (2000-1150 B.P.). This includes pottery and the expansion of a highly sophisticated form of large scale communal bison hunting (Kornfeld et al 2010:125). The Besant projectile point is described as a lanceolate Side-Notched projectile point with bases that range from convex to straight to concave with wide shallow notches. Whether these points were hafted to atlatl darts or to arrow shafts is yet to be widely accepted. Outside of the three previously mentioned projectile points possibly associated with Besant (Outlook, Bratton, Sandy Creek), two other basic styles are known, Besant Side-notched (McLean and Coteau round-shouldered varieties) and Samantha (large and small, I and II varieties) (Cloutier 2004:2; Kehoe 1974:104,108). The Samantha points are thought to be a possible transitional form to Avonlea and represent either the adoption of the bow and arrow (Kehoe 1974:111-113) or high speed low impact atlatl darts (Gregg et al 1996:85). The other hallmark of the Late Period is the widely recognized appearance of the bow and arrow. Dyck and Morlan (1995) suggest that the bow and arrow may have been occasionally adopted as far back as early Pelican Lake and late McKean series, however, accepted wide scale adoption of the bow and arrow is not seen until the later Avonlea complex. Besant pottery is conical and elongated in shape with a lip that extends exteriorly from the vessel, is sand or grit tempered, and constructed by a paddle and anvil (Dyck 1983:115; Walde et al 1995:18). The surface finish is either cord-marked or smoothed, a row of punctuates or bosses below the rim is the most common decoration (Dyck 1983:115; Walde et al 1995:18).

As mentioned, several traits are shared between some of the Late Pelican Lake or possible very early Besant assemblages (Outlook Side-notched, Bratton, Sandy Creek, etc.) and the Besant complex. These traits include bone uprights and a preference for Knife River Flint (Cloutier 2004:19). These traits are also present in Sonota. Sonota is described as a southern expression of Besant in which there is an increased occurrence of ceramics similar to Eastern Woodland pottery, an increase amount of Knife River Flint, and the use of burial mounds (Hjermstad 1996; Walde 2006). The Fitzgerald Site (ElNp-8) is an example of the effectiveness of the Besant peoples at impounding bison, with the remains of upwards of 800 bison within the kill site and processing area (Hjermstad 1996:253). The origin of Besant is linked to either earlier forest fringe groups returning to the plains or developing out of Middle Woodland groups in the Middle Missouri region (Reeves 1983).

The high percentages of Knife River Flint in kill sites such as the Fitzgerald Site may suggest that these sites represents peoples obtaining Knife River Flint through direct procurement and then traveling north to procure bison, as opposed to obtaining lithic material through trade (Hjermstad 1996:103&253). A discrepancy between Knife River Flint percentages at kill sites versus habitation sites suggest a possible difference in the utilization of Knife River Flint, or could represent two different social groups (Walde et al 1995:18-19). This could suggest two separate populations; a migrant Sonota group (southern Besant) that seasonally moved into areas occupied by northern Besant people. The Besant complex may consist of both an intrusive (earlier Outlook, and later Sonota) and a regional population that over time from the developed into Besant from late Pelican Lake phases to mimic cultural entity that continued to make bison procuring forays onto the Northern Plains. Alternatively it is suggested that the Besant people may have been the that first to adopt semi-sedentary tribalism as a way to defend against being pushed out of the Northern Plains by tribally organized semi-sedentary horticultural peoples (Walde 2006:300). Walde (2006:305) suggests that improved storage techniques and hunting strategies that allowed the bison to be brought to "them" (such as pounds or jumps), and pressure from outside groups allowed for the Plains groups of Saskatchewan and surrounding areas to adopt a tribal level of organization prior to the arrival of the horse and gun.

Besant complex sites are the most recognized complex on the Northern Plains (Dyck 1983:114). The increased number of Besant sites in Saskatchewan could be a result of the increase of population which both would require, and be required to support, a tribally-organized society. This increase of sites alternatively may be a result of amplified incursions of tribally organized people from the south and a local population that through diffusion was slowly adopting, or strongly influenced by those southern cultures, as several late Pelican Lake point styles are seen as intermediate to Besant (Kehoe 1974). Simple misidentification with earlier side-notched varieties (Walde et al 1995:18) may also be the reason for this increased site density. The Besant complex retreats from the majority of the Northern Plains region as it is replaced by Avonlea phase. Besant does remain later in the Dakotas than elsewhere possibly solidifying this region as a place of origin of a portion of the cultural manifestation (Frison et al 1996:25).

Chapter 3
Methods

Within archaeological science, a vast array of methods are utilized in almost every aspect of the discipline. Such methodologies include; the way in which we excavate, how we record and catalogue our findings, and how we analyze them. Depending on the nature of the research being done, the archaeologist undertaking the work may have no control over one or more of these areas. Such is the case with this research. As this research relies on sites that have been previously excavated, the methodology that was utilized has been entirely dependent on the original methods used to excavate these sites.

3.1 Projectile Point Analysis

For many people growing up on the Plains, the projectile point has been the quintessential artifact, being the most recognizable man made stone tool found in the plowed fields and stream banks. However as archaeologists, our fascination with projectile points goes beyond the apparent beauty to the functional aspects. The projectile point must be considered a small part of a much larger complex weapons system that can include a foreshaft, a mainshaft, a fletched shaft and fletching (Christenson 1986:114). Just as the projectile point is a small part of a weapon system, it is also a very small part of the overall material culture left behind by past peoples. The wealth of knowledge that can be generated from an entire assemblage is not taken for granted in this project. Nevertheless, the focus here will be on defining projectile point typologies and assigning samples from excavated assemblages into these typologies. The projectile point assemblages recovered from the Mortlach (EcNl-1), Long Creek (DgMr-1), Walter Felt (EcMn-8), Sjovold (EiNs-4), Crane (DiMv-93), Smyth (DjPm-116), Rocky Island (FaNp-7), Fitzgerald (ElNp-8), and Fincastle (DlOx-5) sites are compared to determine whether or not these subjective point styles used on the Plains constitute individual typologies. If this is not the case, to which existing type should they be placed? And is the change in point delivery system responsible for the apparent change in point types? These assemblages will be discussed in more detail in chapter 4.

3.2 Previous Work on Projectile Points

Of the many projectile point-based studies, most can be grouped into two general categories: (1) those that employ more traditional measurements and qualitative data, and (2) those that focus on the change of overall shape. The former are the more common and recognizable in the literature. This is a result of the ease of acquiring such measurements due to the overlap in the cataloguing process between the projectile point measurements and standard measurements for other lithic artifacts.

Research and analysis involving traditional measurement is where a few disjunct collections of metric qualitative traits are utilized to form projectile point types or to distinguish between point types that have been around since some of the earliest scientific excavations (Bettinger et al 1991, Dyck 1983, Dyck and Morlan 1995, Hjermstad 1996, Kehoe 1966 & 1974, Kehoe and McCorquodale 1961, Peck 2011, Peck and Ives 2001, Ramsay 1991, Thomas 1981, Varsakis 2006, Wettlaufer 1955, Wettlaufer and Mayer-Oakes 1960). These studies excel at showing both the trends in the data and what specific measurement or qualitative attribute define a group, but most seem to lack the bigger picture of shape change and just give truncated segments of change. An approach that looks at the wider morphological picture better shows the change and variation between types. Very seldomly is one metric trait or qualitative attribute unique and representative of just one point style. These morphological variations are better used in concert.

Some of the earliest work which analyzed the change of overall shape in projectile point was by Holmer (1978). In studying projectile points from the Early Middle Period in the Great Basin, he used a series of locations on a projectile point and measured distances and angles from one location to another. He determined that the easiest way to measure and plot these values is to digitize the projectile points or pictures thereof if the original is not available. Holmer also outlined several advantages to digitizing the images: (1) virtually all applicable distances and angles can be easily calculated; (2) it offers highly standardized measurement locations; (3) it is an expedient procedure (possibly the most useful aspect) and (4) measurements can be taken on images at any scale allowing analysis of type sites from which the projectile points have gone missing or analyzing assemblages that are unavailable. The coordinate points he used in his analysis include seven coordinate points as follows (Figure 3.1); P1 – centre of the base (for his digitizing method x=0 on a Cartesian grid); P2 – maximum horizontal extant of the basal concavity or convexity; P3 – lower (proximal) corner of the notch opening (for corner-notched and stemmed points will equal P2); P4 – maximum inward extent of notch; P5 – upper (distal) corner of notch opening; P6 – edge of the blade approximately half the length of the blade; P7 – the blade tip (x=0) (Holmer 1978:8). With these measurements Holmer then used discriminate functions to distinguish between projectile points based on the differences in the measurements and angles derived from his digitization of the points. He was able to separate out different point subjective styles with a high degree of success (95%) using two equations (Holmer 1978:20).

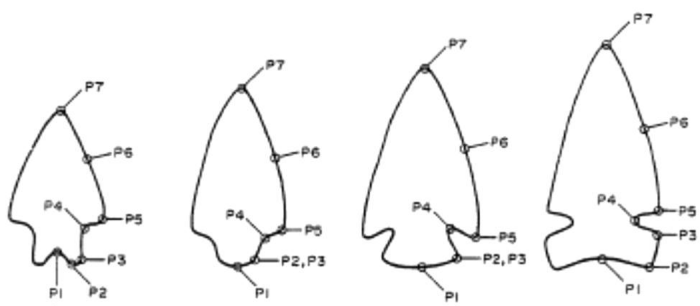

Figure 3.1 Examples of Coordinate Points (Holmer 1978:7 used with permission).

While working on the material from the Gowen Sites, Walker (1992) wanted to determine if projectile points from the Northern Plains during the Early Middle period could be separated similarly to how they had been in the Great Basin. Walker (1992) utilized Holmer's method of classification and achieved a success rate of 84%. This, according to Walker, was a result of the point typology for the Archaic (Middle Period) in the Great Basin being much better defined than Early Middle Period points on the Great Plains (Walker 1992:136-137). These two early landmark based studies of projectile point variation will be the framework on which the landmarks chosen for this study will be utilized and subsequently modified.

Table 3.1 Variables used in the Discriminant Analysis, adapted from Walker (1992:136).

Angle[1]	Definition	Distance[2]	Definition
A1	Angle from P1 to P2	D1	Distance from P1 to P2
A2	Angle from P2 to P3	D2	Distance from P2 to P3
A3	Angle from P3 to P4	D3	Distance from P3 to P4
A4	Angle from P4 to P5	D4	Distance from P4 to P5
A5	Angle from P3 to P5	D5	Distance from P3 to P5
A6	A3 + A4 + A5	D6	Distance from P5 to longitudinal axis (x=0)
		D7	Distance from P1 to P5

1 measured in horizontal radians; 2 measured in centimetres

Two other earlier studies touch upon what would be considered at present geometric morphometrics. Dibble and Chase (1981) attempted to create an impartial and repeatable method of recording artifact data. They set up a scalable rig over the artifact to record dimensions (basically landmarks) where preset transect intersected the margins of the artifact. They utilized landmarks to record shape variation and devised a low tech version of modern digitizing software. Henton and Durand (1991) used a much different approach. They designed a raster based approach to classifying projectile points from Nevada. In their research, simple binary images of projectile points were created and data were recorded along lines that transected the projectile points. In comparison to this key, their raster-based approach achieved a successful classification rate of 79% (Henton and Durand 1991:70).

In the past decade an increasing number of projectile point studies have been utilizing the geometric morphometrics approach (Buchanan 2005; Buchanan et al 2007; Buchanan and Collard 2010; Buchanan et al 2012; Cardillo 2010; and Iovita 2011). These studies compare everything from point reduction to classification to hafting techniques. All of these analyses utilize mostly intact projectile points and focus on the overall shape change using the outline of the point.

Only forty-three percent (43%) of the points currently in the study are considered complete; unlike the assemblages studied in the aforementioned analyses, the luxury of a largely complete collection is not afforded in this study. As the sample in this study is not large enough to allow the exclusion of broken or damaged points, landmarks will be used and placed to try and capture shape change on the proximal (basal) half of projectile points. This focus on the proximal portion of the point is also influenced by previous work (Flenniken and Raymond 1986, Holmer 1978, Varsakis 2006, Walker 1992) in which has been noted that the basal region is the least modified by rejuvenation. This process can be employed to compare assemblages from the Terminal Middle period utilizing a landmark based geometric morphometrics approach.

3.3 Geometric Morphometrics

Morphometrics is a branch of mathematical shape theory that is a quantitative way of addressing shape comparisons (Zelditch et al 2004:1). These comparisons use an intangible language that is often complicated. Geometric morphometrics (GMM) serves as a way to visualize these highly abstract values as the geometric representations of the change are easier to understand than vast tables of numbers and equations. The basics of creating a shape that is to be analyzed in GMM is through the use of landmarks that record shape data. "Landmarks are discrete anatomical loci that can be recognized as the same loci in all specimens" (Zelditch et all 2004:23). The locations chosen to be used as landmarks should reflect the changes that can be seen. There are three types of landmarks as well as an additional type that acts as a pseudo-landmark. Type one landmarks are homologous structures easily identifiable across projectile points. Type two landmarks represent maximum or minimum position along the curvature of shape boundary. Type three landmarks represent maximum or minimum end points. The pseudo-landmarks represent landmarks placed to attempt to track change that is not covered by the previous types of landmarks (Bookstein 1991; Buchanan 2007; Zelditch et al 2004).

3.3.1 Assemblages and Sample Size

As with any attempt to compare projectile points, larger sample sizes create more robust results, and so the sites chosen here were ones containing large assemblages of projectile points. Where possible, these assemblages where chosen following several criteria: (a) they represented type site material, (b) derived from components with a definitive stratigraphic separation, and (c) had radiocarbon dates either pertaining to the components or the components of interest are bracketed by dates. The radiocarbon dates used in this thesis are uncalibrated dates. The stylistic groups used in this study were based on the assemblages and styles proposed by the original investigators of these sites, such as Wettlaufer (1955), Wettlaufer and Mayer-Oakes (1960), Dyck and Morlan (1995), Hjermstad (1996), Varsakis (2006), Gibson and McKeand (2010), as well as subsequent studies on the sites such as those done by Kehoe (1974), Dyck (1983), and Peck (2011). However, three composite point groups were created in order to increase the sample sizes of three "original" point styles: Besant, Sandy Creek, and Pelican Lake. These composite groups used projectile point classification outlined by Wettlaufer (1955), Wettlaufer and Mayer-Oakes (1960), Dyck (1983), Dyck and Morlan (1995) and Kehoe (1974), and used points from the Mortlach Site (EcNm-1) to create the Besant group; the Mortlach (EcNl-1) and Sjovold (EiNs-4) sites to create the Sandy Creek group; and the Mortlach (EcNl-1), Long Creek (DgMr-1), Walter Felt (EcNm-8), and Crane (DiMv-93) sites to create the Pelican Lake group.

A total of 291 projectile points were examined. Of that number, several specimens were not included because they were too fragmentary or their stratigraphic position was of suspect due to mixed assemblages, stratigraphic compression, or lack of records. Flake points were also excluded as they are seen as more expedient tools with less care taken in their manufacture; thus, they may not maintain stylistic differences (Hjermstad 1996:57; Dawe 1997:305). These factors reduced the number of points used in the GMM analysis to 174. In addition to the data collected through the digitizing process (see below), more traditional measurements and data were recorded for all 291 points. These additional attributes recorded were based on those employed by Ramsey (1991), Hjermstad (1996), and Varsakis (2006) in their studies of Besant/Sonota projectile points. These include quantitative measurements such as weight, maximum length, shoulder width, maximum thickness, base width, shoulder height (left and right), notch depth (left and right), basal height (left and right), and neck width. Qualitative data such as longitudinal and transverse cross sections, lithic material, basal shape, notch forms, basal juncture and edge shape, shoulder shape, haft type, and basal edge modification were also recorded. Often these data were collected from the tables in the original site publications or manuscripts. When these data were unavailable, the author gathered it from published pictures from theses or site reports. The only three data fields that could not be completed in this manner were weight, thickness, and basal modification, so if they were not specifically mentioned in the previous work they were left out. This collection process was aided by the use of the thin plate spline digitizing program (tpsDIG2 v2.16) developed by Rohlf (2010). The use of this software allowed for measurements to the nearest 1/10 of a millimetre to be recorded. While this level of accuracy is far beyond the level of accuracy required for the current analysis, it shows the capabilities of the digitizing process. For instance, the program allowed more accurate notch depths to be recorded with the placement of reference lines on the specimen.

3.3.2 Photographs and digitizing

The modern digitization process maintains and exemplifies the same advantages as those previously mentioned by Holmer (1978): (1) all the values for the angles and distances can be easily calculated; (2) the locations of the values are standardized; (3) it is fast, and (4) where work was based off of pictures the scale can be converted to a standard one (Holmer 1978:6&8). As GMM is concerned with shape change, the first advantage is computed differently but is still easily attained. The values used by Holmer as well as several others (virtually any measurement other than weight) can be generated from the digital pictures in mere moments. Such measurements would be very difficult to standardize and collect via traditional methods. Depending on the software used, such measurements can be saved onto the image to allow subsequent researchers to use similar data. The standardized locations can be found and assigned as landmarks easily and quickly. Nearly any picture that includes a scale or where a scale can be ascertained can be used in a standardized fashion.

Using the same thin plate spline digitizing program (tpsDIG2), a total of fourteen landmarks were placed on each of the 174 digital images. The digital images were captured in one of two ways. The first involved a photograph being taken of the physical projectile point using a Pentax K5 digital camera mounted on a photo stand located 25cm above the artifact with a standard scale. In the event the physical artifacts where not obtained, a second method involving a published manuscript or PDF file with a scale bar was used. These original pictures were scanned and the landmarks were digitized on the new digital image. A slight alteration to this process was done for assemblages where a scale bar was not present in the original document. This only was only encountered for the Mortlach site (EcNl-1). The pictures were recorded as a one-to-one scale in the monograph, and this was validated by comparing the obtained physical artifacts with their counterparts on the plates in the original publication. A scale ruler was placed on the picture and a photo was taken of the plate in the book, as the plate did not scan well. Once the images were captured they were combined into TPS files in a program called tpsUtil v1.53 (Rohlf 2012). The photos were combined in relation to the assemblage where they originated. These smaller groups would be later combined into a master file that was used to compare all the groups to each other.

Of the fourteen (14) landmarks (LM) used in this study, twelve (12) were located on each projectile point and two (2) were on the scale. I followed Holmer's (1978) and Walker's (1992) lead in landmark placement. Four (4) of the landmarks were considered type one landmarks (Bookstein 1991): LM3 and LM11 the proximal opening of the notch, and LM5 and LM8 the distal opening of the notch. Five (5) of the landmarks were considered type two landmarks (Bookstein 1991): LM1 the middle of the point's base, LM2 and LM12 the maximum lateral extent of the basal convexity or concavity, and LM4 and LM10 the maximum depth of the notch. The remaining three (3) landmarks are considered type three or pseudo landmarks (Bookstein 1991). These include LM6 and LM9 which were placed 0.5 centimetres above the distal opening of the notch along the blade, and LM7 which was placed 1.5 centimetres above LM1 along the point's midline. As many of the projectile points were missing their tips and/or lateral edges, no attempt was made to capture any data pertaining to the tip or the blade beyond 0.5cm above the haft. Such data were also avoided as both Holmer (1978:17&20) and Walker (1992:135) found the length to be irrelevant as the practice of reshaping or outright abandonment of broken points meant the original length or any length in general was inaccessible. The remaining two (2) landmarks were placed on the scale at a set interval of 1 centimetre to allow for proper scaling of the projectile points. The landmarks were placed in counter clockwise fashion in numerical order starting at the middle of the base (LM1) ending with the maximum lateral extent of the basal convexity or concavity (LM12). An exception occurs with LM8 and LM9 as the location of LM8 would need to be determined (distal notch opening) before LM9 (0.5cm above LM8) can be determined. Landmarks LM13 and LM14 are those found on the scale (Figure 3.2).

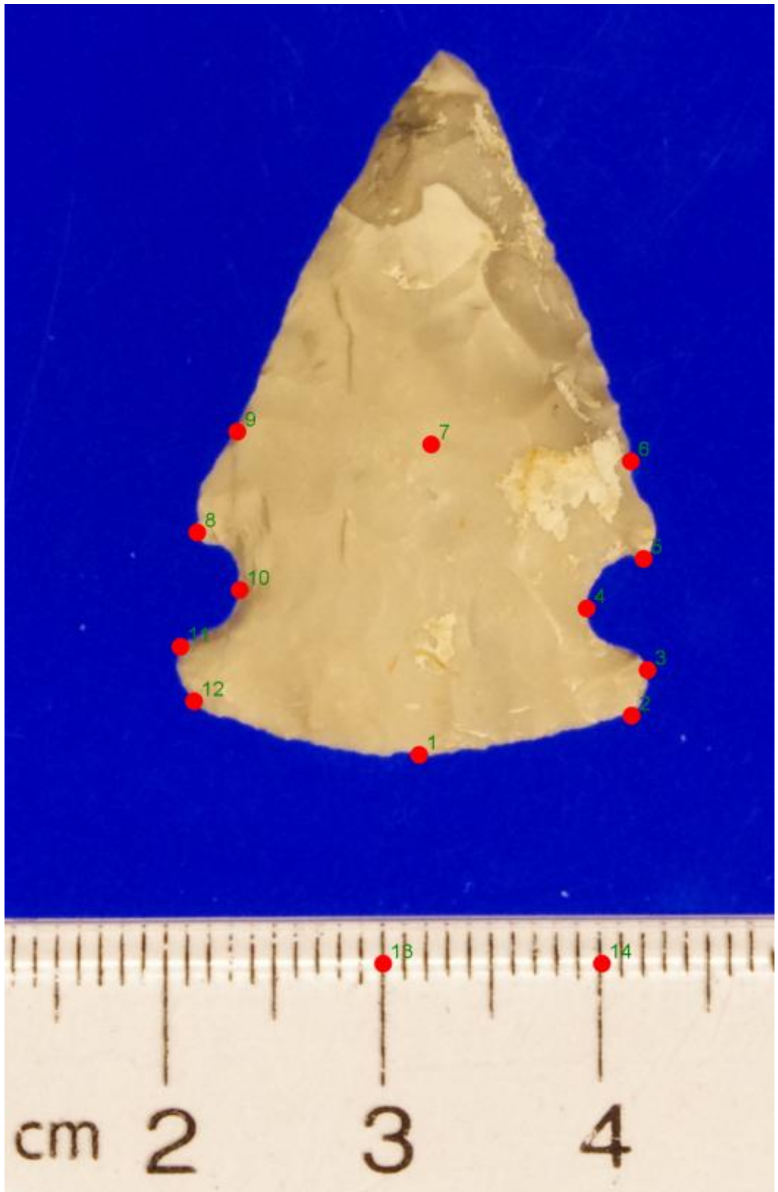

Figure 3.2 Representative projectile point with locations and numbering of the Landmarks.

Projectile points are described as generally being symmetrical along their long axis. In some previous studies (Holmer 1978, Walker 1992) both sides have been measured independently. This approach is not without problems. Measuring both sides independently of each other, unless asymmetry is the purpose of the study, inflates the degrees of freedom, which demands large sample sizes as consequence (Zelditch et al 2004:67). In order to negate this issue, software programmed by Sheets (2001) known as BigFix6 reflects landmarks from one side of the axis to another. It takes the average of the landmarks from both sides and creates new coordinates for the reflected landmarks. This reflection across the plane of symmetry is also utilized to provide landmark data for the missing values associated with broken projectile points used in the study. Should a landmark be missing on one side due to breakage, its partner coordinate on the reverse side will be used in its place. The resulting configuration of averaged landmarks is seen in Figure 3.3 and represents LM's 1 through 7 labeled on the figure (the corresponding landmark configuration is rotated clockwise 90 degrees).

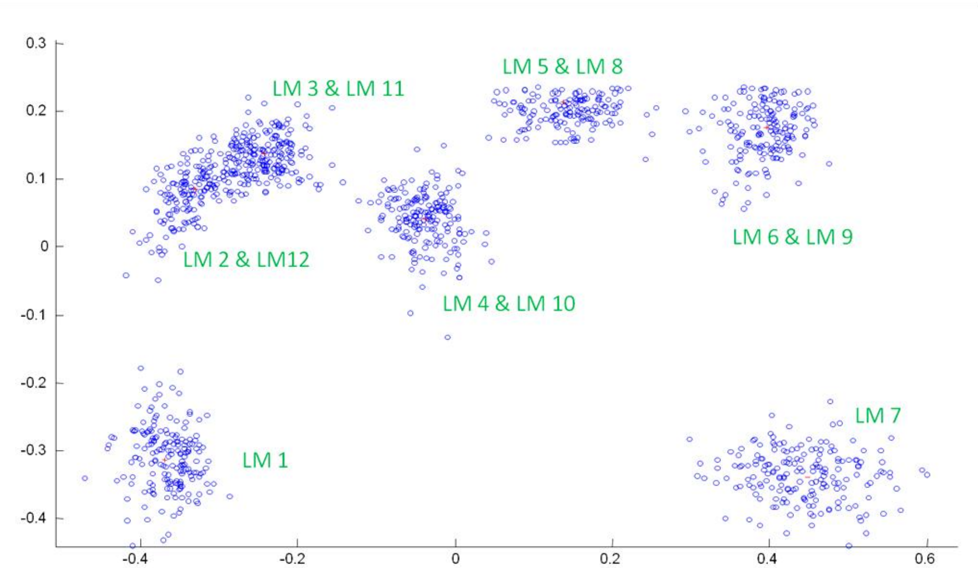

Figure 3.3 Locations of Landmarks after Reflection and Generalized Procrustes Fit.

3.3.3 Superposition, Ordination, and Exploratory Techniques

The files of the newly reflected landmarks are loaded into the program MorphoJ v1.05c (Klingenberg 2012) for further analysis. In this program superposition is achieved using a Procrustes superposition. This superpostional method allows for removal via translation, scaling, and rotation of all information unrelated to shape (Zelditch et al 2004:113). A centroid and a log centroid size are also generated in this process. As a general rule of thumb, the number of landmarks should not exceed the number of individuals in the smallest group (Bookstein 1991, Zelditch et al 2004). The smallest main groups' size is five (5), so with this in mind LM6 and LM7 were excluded and a new Procrustes fit was performed. This reduction in LM's was not unfounded. Since LM7 was included to serve as one anchor of the baseline it was deemed unnecessary as both Holmer (1978) and Walker (1992) note length is not of great importance to distinguishing between Early Middle Period projectile points so the same approach was applied to the Terminal Middle Period projectile points. LM6 was originally included to represent a change in blade morphology. LM6 was deemed to be of little consequence as the area outside of the haft is highly subject to change as a result of rejuvenation (Walker 1992:135, Varsakis 2006:128) and was subsequently removed from the analysis. The resulting configuration of landmarks is seen in Figure 3.4. This figure (Figure 3.4) also shows an example of the wireframe graphs that are presented in relation to the DFA and cluster analysis data presented in chapter 5 and in Appendix B, C, and D. The image is a representation of the outline that is formed between the reflected and averaged landmarks, note that the landmarks are no longer on the locations they were on in Figure 3.2. From now on the different wireframe outlines you will see are a representation of the outlines formed by connecting the reflected and averaged landmarks on the respective projectile point types illustrated in the following figures.

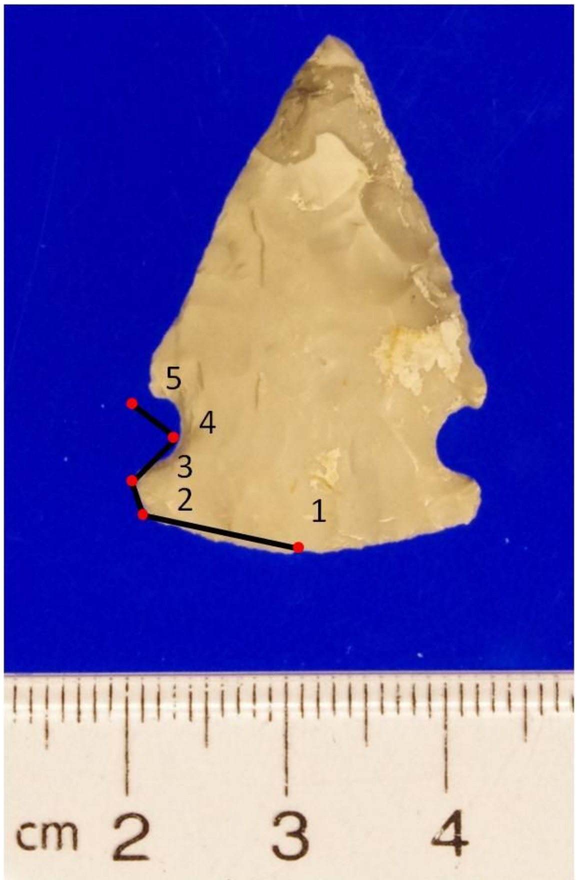

Figure 3.4 Representation of final Landmark configuration and Wireframe Graph.

3.3.4 Canonical Variate Analysis and UPGAMA Cluster Analysis

In order to remove size as a factor in the analysis, a linear regression was applied within the MorphoJ software, and since group structure was to be considered, the size correction was done as a pooled within-group linear regression. After the regression was applied to the Procrustes coordinates, a Canonical Variate Analysis (CVA) was then performed to act as a simplified multi group discriminate function analysis. “The purpose of CVA is to simplify and visualize the differences among groups” of individuals and their means (Zelditch et al 2004:170). CVA constructs a new coordinate system (canonical variates CV’s) and determines the placement of each individual in the study along these new axes. Scaling occurs along the axis so the distance portrayed in the CVA is not the distances present in the original shape space (Zelditch et al 2004:170). The CV’s created by the CVA process represent the axes that the groups are best discriminated along (Strauss 2010:77; Zelditch 2004:171). Beyond a simplified graphical output the CVA process in MorphoJ also creates both Mahalanobis and Procrustes distances and associated p-values. The “Mahalanobis distances are seen as analogous to using an F-statistic...” but differ in that a Mahalanobis distance “...approaches its “true” value with increasing sample sizes” (Strauss 2010:83). The Mahalanobis distances themselves can best be explained in terms of metric measurements. Strauss (2010:83) describes the metric qualities that Mahalanobis distances meet as such:

> the distance between two identical points must be zero, the distance between two non-identical points must be greater than zero, the distance from A to B must be the same as that from B to A (symmetry), and the pairwise distances among three points must satisfy the triangle inequality. For morphometric data, such a measure of group separation is ....informative [as the] distance between groups.

The Procrustes distances are similar to the Mahalanobis distances. It is the distance between two landmark configurations in shape space. It is roughly the square root of summed squares distances between two homologous landmarks in a Procrustes superimposition (Zelditch et al 2004). In this study, as computational power was not an issue, 10,000 permutation tests were run on each Mahalanobis and Procrustes distance. The permutation tests act to test the significance of the distances. These tests utilize a null hypothesis of statistically separate populations (or assemblages). Meaning the closer to zero the p-value is for any two assemblages the less likely the two assemblages derived from the same population. This allows for an idea of the uniqueness of the assemblages as running the test one determines the likelihood that the assemblages are randomly divided. A more in depth, discussion of regression, canonical variate analysis, and

GMM is beyond the scope of this thesis, as such additional information can be found in *Geometric Morphometrics for Biologist*, (Zelditch et al 2004), *Morphometrics for Nonmorphometicians* (Elewa 2010), or the MorphoJ manual (Klingenberg 2012).

Using cluster analysis, a diagrammatic representation of the CVA data was created to show the relationships between point styles similarities and differences. It was created using the Mahalanobis distances, procrustes distances, and associated p-values between groups/assemblages. The cluster analysis utilized an UPGMA (Unweighted Pair Group Method and Arithmetic Mean) approach. This was done in a program designed by W. Maddison and D. Maddison (2011), called Mesquite v2.75.

3.3.5 Discriminate Function Analysis

In order to define projectile points into styles beyond subjective visual separation, discriminate function analysis (DFA) was used. Previous authors (Holmer 1978; Walker 1992) have used this approach to separate and create point typologies for the Great Basin Archaic (Middle Period) and the Early Middle Period on the Great Plains respectively. I intend to use this approach to determine if the subjective point categories in the Terminal Middle Period/Late Period Transition (Pelican Lake, Bracken, Outlook, Bratton, Sandy Creek, Sonota, and Besant) proposed by several authors constitute mathematically distinct point types (Dyck and Morlan 1995; Kehoe 1974; Peck 2011). A discriminate function statistic is a linear combination of variables that that can be used to distinguish or combine groups of individuals (Strauss 2010:74). In the case of GMM, these variables are based on the shape coordinates. The results of the linear combinations used in this thesis were also generated using the MorphoJ software. These combinations are shown in an easy to visualize manner. In order to test the "goodness of fit" of the DFA model, cross validation scores are calculated. These cross validation scores give a better representation of the model than the original DFA (Kovarovic et al 2011; Strauss 2010). Cross validation scores work on the principle of "leave one out" analysis. The basis of which uses n-1 (where n is the sample size) to create the model then tests the individual that was left out to see where it fits. This process is then repeated so all the individuals have been left out (Strauss 2010). It is also pointed out by Strauss (2010) that it is better suited to smaller samples than the original DFA. In essence, cross validation tests how well the DFA model can predict the data used to create it.

This information will be used in an attempt to clarify the intricate projectile point complexes that are postulated to have existed during the end of the Middle Period and the beginning of the Late Period on the Northern Plains. In addition to attempting to assign projectile points to typologies, the projectile points will also be analyzed to determine if they are arrow or atlatl dart tips using a one of several statistical equations outlined by Thomas (1978), Shott (1997), Knight and Keyser (1983), Bradbury (1997) or Hildebrandt and King (2012). These equations will be tested against a control group to determine which equation works best for projectile points common to the Northern Plains This will be done to see if the introduction of the bow and arrow is may have played a causal role in the rise of the great diversity of projectile point morphologies present at the aforementioned sites.

3.4 Metric Classification of Arrow and Atlatl points

The adoption of the bow and arrow is seen as one of the defining characteristics of the Late Period (2000 – 200 B.P.). The possibility of its earlier adoption has been suggested by several authors (Bradbury 1997; Dyck 1983; Dyck and Morlan 1995; Kehoe 1974). If it was introduced earlier it probably served alongside the atlatl for centuries (Bradbury 1997:210). The advantages of the bow and arrow over the atlatl are outlined by Christenson (1986:122) as follows: (1) greater accuracy; (2) a longer effective range; (3) a smaller range of motion for use; (4) a higher rate of fire, and can carry more projectiles in the same amount of space; (5) arrow points and shafts require less material and due to size easier to make; (6) a shorter learning curve. Although fewer in numbers, Christenson (1986:122) also supplies reason why the atlatl would be superior to the bow and arrow; (1) the atlatl requires only one hand to use; (2) the atlatl itself is easier to manufacture and maintain than a bow; (3) the dart has a higher impact force than the arrow. In order to assign a projectile point into a category such as atlatl or arrow beyond a relatively unreliable visual placement, classification functions are used. The data gathered for this analysis on the projectile point assemblages studied in this thesis was done independently of the GMM analysis and was not subjected to or impacted by the linear regression preformed on the GMM data.

Several equations have been developed to statically assign projectile points into a category of either arrow or atlatl. The first such equation was developed by Thomas (1978:470). He examined ethnographic samples from museums and collections that were still retained in the haft or were associated with arrow or atlatl foreshafts. He used length, width, neck width, and thickness in the discriminant functions. Unfortunately his sample size for atlatl darts (10) was very small in relation to that for the arrows (132) (Thomas 1978:471).

Equation 1 Thomas (1978) Four Variables

Dart = (0.188 x Length) + (1.205 x Width) + (0.392 x Thickness) - (0.223 x Neck) - 17.552

Arrow = (0.108 x Length) + (0.470 x Width) + (0.864 x Thickness) + (0.214 x Neck) - 7.922

Shott (1997:87) took Thomas' equation and reworked it in light of an expanded atlatl data set (29) to be included into the original data for atlatl (n=10), and arrows (n=132). Shott (1997:93-95) recalculations of Thomas' equation were done using a four, three, two, and one variables equations, the three and one variable equations will be used here as they had the highest degree of accuracy in the initial study. Instead of utilizing all of Thomas variables, Shott used width (which he used shoulder width for), thickness, and neck width in his three variable equation, and width in his single variable equation.

Equation 2 Shott (1997) Three Variables

Dart = (1.24 x Width) + (1.94 x Thickness) + (0.38 x Neck) - 22.7

Arrow = (0.69 x Width) + (2.05 x Thickness) + (0.19 x Neck) - 10.7

Equation 3 Shott (1997) One Variable

Dart = (1.40 x Width) -16.85

Arrow = (0.89 x Width) - 7.22

Knight and Keyser (1983) also employed Thomas' original equation (Equation 4) but used an entirely different data set. The data set they used was significantly larger then Thomas' with respect to atlatl darts (n=88) and marginally larger for arrows (n=134). Instead of using ethnographic and museum examples that were known to be darts or arrows, Knight and Keyser (1983:203-205) used points from data components of sites on the Northwestern Plains (southern Montana and northwestern Wyoming) believed to represent atlatl darts or arrows. Knight and

Keyser (1983:205) also developed a single variable equation (Equation 5) utilizing only neck width. The objective of these equations was to determine if surface finds in the area would be Late Prehistoric (Late Period) or Archaic (Middle Period) (Knight and Keyser 1983:202). Although not directly related to the use of the atlatl and bow and arrow, the Middle Period is largely seen as a time period in which the atlatl was used most regularly is not exclusively, while the Late Period is seen as a time period when the bow and arrow was widely used. Unlike the other equations this one is focused on Plains projectile points.

Equation 4 Knight and Keyser (1983) Four Variables

Middle Period = (0.1217 x Length) + (2.3532 x Width) + (8.6414 x Thickness) + (2.5292 x Neck) - 63.8418

Late Period = (0.0605 x Length) + (1.5859 x Width) + (5.4299 x Thickness) + (2.0276 x Neck) - 30.1229

Equation 5 Knight and Keyser (1983) One Variable

Middle Period = (4.6610 x Neck) - 31.1752

Late Period = (3.205 x Neck) - 15.3356

Bradbury (1997) also reworked Thomas' original equation using the original data set, but limited the variables to just width and neck width (Equation 6), as length and thickness can be modified through usage. His equation, much like Thomas' and Shotts', was designed to distinguish between arrow and atlatl points. Although focusing on variables that were least likely to change in the rejuvenation process, he suffered from the same sample size problems that Thomas did earlier.

Equation 6 Bradbury (1997) Two Variables

Dart = (1.420838 x Width) + (0.05398166 x Neck) - 17.31622

Arrow = (0.6320802 x Width) + (0.5082722 x Neck) - 7.86771

Hildebrandt and King (2012) took a different approach to this problem. Their equation looked at the point attributes that changed the least in the rejuvenation process, neck width and maximum thickness. As a result of Flenniken and Raymond's (1986) research these attributes were found to remain the closest to their true value. From this research, the neck width and maximum thickness were deemed to have only changed by 5.5 and 3.9 percent respectively compared to the other common attributes used in this type of analysis, in which changes were observed in the neighborhood of 28.6 to 11.1 percent (Hildebrandt and King 2012:791). From this data Hildebrandt and King (2012) derived the equation below (Equation 7). The Dart-Arrow index of 11.8mm was determined from an index value on a bimodal curve on which all of the projectile point scores for their research was plotted. This equation's potential is greater than the other equations because of its simplicity and the fact it utilizes portions of projectile point that do not change with rejuvenation.

Equation 7 Hildebrandt and King (2012)

Neck Width + Maximum Thickness = Dart-Arrow Index

Dart > 11.8mm < Arrow

In order to test the validity of the equations a sample of projectile points was used from the teaching reference collection at the University of Saskatchewan. The projectile points selected date from the Early Middle and Mid Middle Periods, and the later portion of the Late Period, so as to pre and postdate the generally accepted arrival of the bow and arrow on the plains. The points used as the atlatl control as they are display left to right in Figure 3.4, starting in the top row, consisted of Early Side-Notched (n=7), Oxbow (n=5), McKean Lanceolate (n=4), Duncan (n=1), and Hanna (n=3), for a total of twenty points. The points used as the arrow control as they are display left to right in Figure 3.5, starting in the top row, consisted of Avonlea (n=4), Prairie Side-Notched (n=8), and Plains Side-Notched (n=8), for a total of twenty points. The scale difference between these two figures (3.4 and 3.5) should be noted. Points from these complexes were chosen as they are believed to predate the bow, are solely associated with use of the bow (Dyck 1983). Pelican Lake and Besant points were purposely excluded from the experiment as it has been suggested that some assemblages from either of these complexes may represent the early adoption of the bow and arrow (Dyck 1983). In addition, some heavily reworked McKean and Hanna points were chosen to see which equations would be affected by heavy reworking. Metrics for the projectile points are listed in Appendix F.

Figure 3.5 Middle Period Projectile Point Sample.

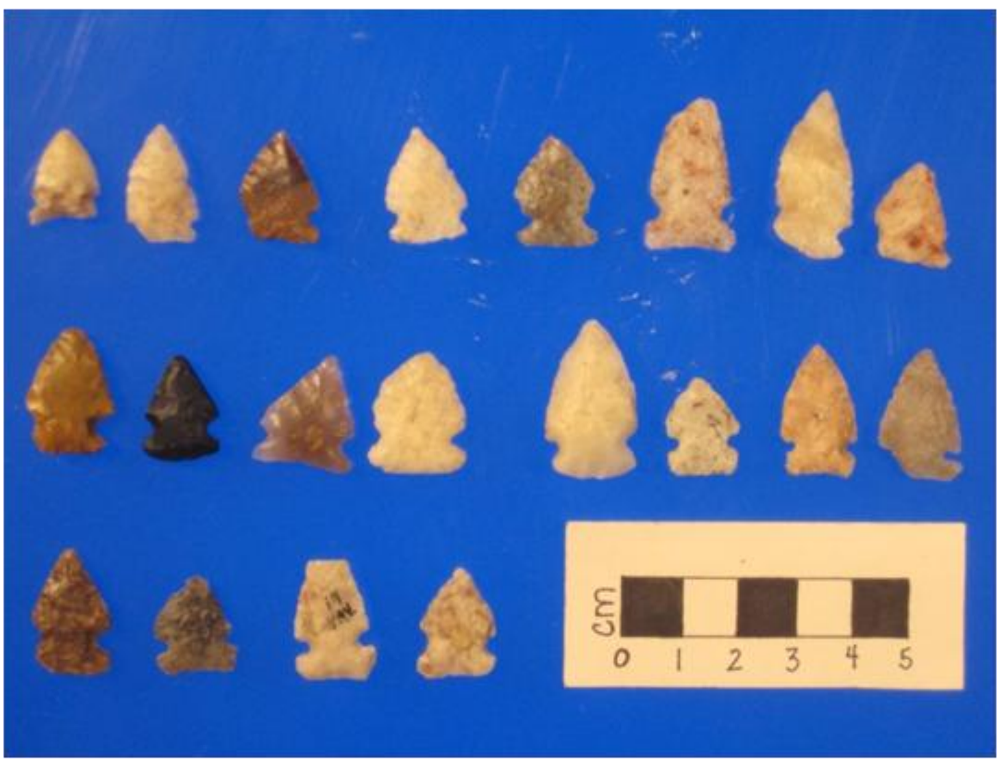

Figure 3.6 Late Period Projectile Point Sample.

The accuracy reported in the articles and that observed within testing conducted are listed in the table (Table 3.2). A result of "No Decision" was returned when the difference between the value for arrow and atlatl was less than 1. Individual results for each equation and projectile point are included in Appendix F.

Table 3.2 Results for selected Discriminant Functions.

Equation	Thomas	Shott (3)	Shott (1)	Knight and Keyser	Knight and Keyser (1)	Bradbury	H & K
Arrow Accuracy (article)	85.2	89.4	92.4	97.1	92.3	89.4	Not Listed
Dart Accuracy (article)	70	84.6	76.9	94.7	89.7	80	Not Listed
Sample Weighted (article)	85.9	89.3	88.9	96.2	91.3	88.7	Not Listed
Overall Accuracy (article)	77.6	87	84.7	95.9	91	84.7	Not Listed
Arrow Accuracy (obs)	100 (20)	100 (20)	100 (20)	90 (18)	80 (16)	100 (20)	5 (1)
Dart Accuracy (obs)	35 (7)	80 (16)	75 (15)	100 (20)	100 (20)	30 (6)	100 (20)
Overall Accuracy (obs)	67.5 (27)	90 (36)	87.5 (35)	95 (38)	90 (36)	65 (26)	52.5 (21)
"No Decisions" (obs)	1	5	10	3	5	7	1
Accuracy – "No Decisions"	66.7	97.1	93.3	97.3	88.6	78.8	53.8

As noted earlier in the chapter Hildebrandt and King's equation (2012) has great potential. However, this equation performed extremely poorly in regards to the Northern Plains projectile point sample (Table 3.2). This brings to light inherent problem with this equation and most other equations; they were all adapted from points and samples from the Great Basin. As will be outlined in Chapter 6, point size is inherently related to game size. The major game species in the Great Basin are pronghorn and rabbits which are very small in comparison to bison, and would require smaller projectile points.

A heavier projectile is desired for larger game such as bison. After a switch to the bow and arrow, the reduction in point size and weight would still require an input of mass. This input of mass would then be left for the arrow shaft to provide. This would increase the neck width, and skew the index point (11.8mm) proposed by Hildebrandt and King (2012) as compared to the Great Basin. In the very small sample size tested here a very definite bimodal curve was results, suggesting the index value should be considerably higher for Northern Plains projectile points. Upon this revelation, the averages for Avonlea, Prairie and Plains side-notched metric values published in Peck and Ives (2001) and Kehoe (1973) were tested, these published averages tested similarly to the control sample tested here. They all were above the index value of 11.8mm. These projectile point styles listed above are all considered arrow points by the large majority of Plains archaeologists. As the control sample size used was too small, a verified new index value was not established. A reworking of this equation with the Northern Plains in mind is beyond the scope of this thesis work and will have to be left for another intrepid archaeologist or archaeologists to tackle.

Despite the possible short comings of these equations to deal with the rejuvenation process, one of the equations tested above will have to be used in this study. The similarities in accuracy between Shotts' and Knight and Keysers', leads to a difficult decision. Even though Knight and Keysers' two equations had a higher degree of accuracy overall, it was not designed to determine if the given point was an arrow or an atlatl. Also this style of test was inherently biased towards these two equations. With that in mind, I will be using Shott's three variable equation as it was designed under a stricter premise with museum pieces being backed up by ethnographic data. In instances where shoulder width, thickness, and neck width cannot be determined, the single variable equation by Shott will be used which requires only shoulder width.

The methods outlined in this chapter show a heavy focus on projectile point typology and function. As one-dimensional as this seems, it is the unfortunate reality of Plains archaeology prior to the appearance of ceramics. In the previous almost century of study on the Plains, aceramic complexes are defined mainly by projectile point typologies. These typologies are seen as chronological and spatial markers. With time period of study (Terminal Middle Period, 2500 B.P.) seen as largely aceramic on this portion of the Plains, I am forced to utilize the data which have been accumulated.

Chapter 4
The Archaeological Data Base

As noted in the previous chapter, the assemblages chosen for this study include those which had the following criteria: (a) represent type site material, (b) have components with a definitive stratigraphic separation, and (c) have radiocarbon dates either pertaining to the components or the components are bracketed by dates. These criteria allowed for the selection of projectile points from the following sites: Mortlach (EcNl-1), Long Creek (DgMr-1), Walter Felt (EcMn-8), Sjovold (EiNs-4), Crane (DiMv-93), Smyth (DjPm-116), Rocky Island (FaNp-7), Fitzgerald (ElNp-8), and Fincastle (DlOx-5). The location of these sites is seen in Figure 4.1. The assemblages and associated levels from these sites are discussed in this chapter. It should be noted that as many projectile points were too fragmentary for analysis or of suspect stratigraphic position, the figures in this chapter will only include those used in the analysis that were not obtained from other printed works.

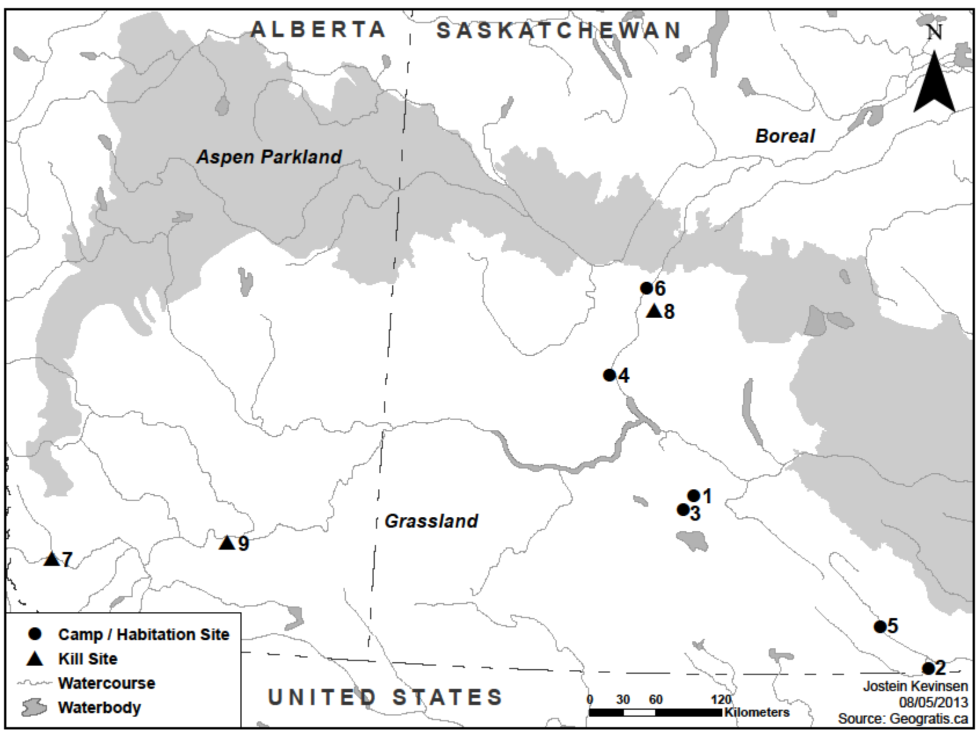

Figure 4.1 Locations of the Archaeological sites utilized in this thesis.

1 = Mortlach (EcNl-1), 2 = Long Creek (DgMr-1), 3 = Walter Felt (EcMn-8),
4 = Sjovold (EiNs-4), 5 = Crane (DiMv-93), 6 = Rocky Island (FaNp-7), 7 = Smyth (DjPm-116),
8 = Fitzgerald (ElNp-8), 9 = Fincastle (DlOx-5)

4.1 The Mortlach Site (EcNl-1)

The Mortlach Site has the distinction of being the first scientifically excavated site in the province. The site is situated in the Besant Valley of south-central Saskatchewan near the community of Mortlach. The excavations conducted by Boyd Wettlaufer in 1952 and 1954 revealed a multi-component habitation site and laid the framework for a large portion of the Northern Plains culture history. Wettlaufer (1955) described the Mortlach, Besant, Sandy Creek, and Pelican Lake cultures from his findings at the site. Only the later three are of consequence to this analysis.

The Besant levels (4A, B, C, and D) are grouped on the basis of projectile point morphology and similarities in cultural material. As only 4A and 4B are widely accepted as Besant, only the projectile points from levels 4A and 4B will be used in this thesis. A date of 1580±325 (S-22) was secured from level 4B (Wettlaufer 1955, CARD 2013). The Sandy Creek material as defined by Wettlaufer (1955) was originally contained to level 4E with an associated date of 2400±290 (S-28) (CARD 2013). Ian Dyck (1983) upon reviewing the material from Mortlach placed level 4D (originally a Besant level) in with Sandy Creek. I will follow Dyck's (1983) interpretation. The Pelican Lake material from the Mortlach site was recovered from levels 5A and B, 6, and 7 (Wettlaufer 1955) though intact and nearly complete projectile points were confined to level 5A. No dates were associated with the Pelican Lake levels; however, the Sandy Creek level above and the Thunder Creek (McKean Series) level below were dated. The McKean Series level dates to 3400±200 (S-2) (Wettlaufer 1955; CARD 2013). Since the Mortlach site is the type site for Besant, Sandy Creek, and Pelican Lake, the projectile points associated with those levels are used in this analysis. Only a select few Besant projectile points (the 4 pictured in Figure 4.2) were available for the study so the remainder of the Besant (5), Sandy Creek (4) and Pelican Lake (3) projectile point assemblages from this site were digitized from the images in Wettlaufer’s manuscript (1955), and compiled into their associated composite groups.

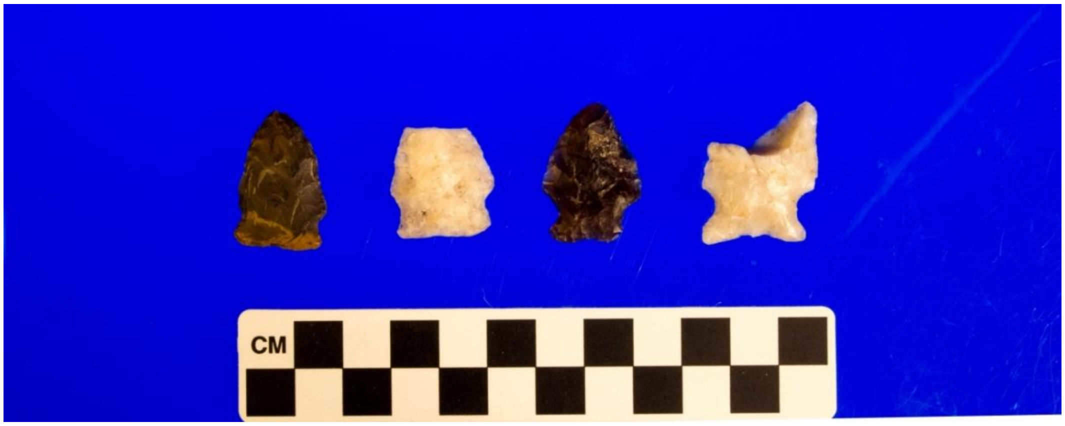

Figure 4.2 Mortlach Site Projectile Points Level 4A.

4.2 The Long Creek Site (DgMr-1)

The Long Creek Site is located just south of Estevan in southeastern Saskatchewan in what was the Long Creek valley. The site was excavated in 1957 in response to proposed dam construction on Long Creek (Wettlaufer and Mayer-Oakes 1960). This site further supported the cultural chronology proposed by Wettlaufer (1955) just a few years before at the Mortlach Site. Nine occupation levels were identified in the original investigation although the cultural affiliations of some of the earliest and latest levels have been reinterpreted by Bryant (2002).

The only level of interest to this analysis, level four, contains Pelican Lake cultural material (Wettlaufer and Mayer-Oakes 1960). Level 4 is split into 4A and a 4B and the affiliation remains unchanged from the original interpretation (Bryant 2002). Four (4) of the six projectile points from the Long Creek Site are used in this analysis. They are those from level 4A. Two (2) dates were recovered from the Long Creek site for level 4. A date of 2230±100 (S-49 a) and is associated with level 4A. The other date of 3710±70 (S-49 b) is also recorded, but this date is thought to be a cataloguing error and is associated with level 5 (Bryant 2002, Wettlaufer and Mayer-Oakes 1960, CARD 2013). As the original artefacts were not available for study the images were digitized from Bryant's thesis (2002) and utilized in the Pelican Lake composite group.

4.3 The Walter Felt Site (EcMn-8)

The Walter Felt site represents a bison pound and campsite located along the edge of the Missouri Coteau south of the community of Mortlach in south-central Saskatchewan (Kehoe

1974). The excavations at the site were undertaken by the Saskatchewan Museum of Natural History (now the Royal Saskatchewan Museum) in 1962 and 1965 headed by Thomas Kehoe (Kehoe 1965, 1974) and in 1966 and 1967 by Gilbert Watson (1966, 1967). Twelve occupational levels were identified.

The upper levels of the site contain Late Period material (Plains and Prairie Side-Notch, as well as Avonlea and mixed Avonlea/Samantha levels (Level 10). Level 13 has been assigned to Besant with a date of 1610±70 (S-200) (Kehoe 1965; CARD 2013). However, level 13 is split into two occupation levels, 13a and 13c. The date is associated with level 13a as this is the deepest the 1962 test excavations went (Kehoe 1965). The first example of pottery in good stratigraphic context that was associated with Besant points in Saskatchewan was found in level 13a (Kehoe 1964). Level 13c is separated from 13a in most units by layer of yellow clay (Kehoe 1965; Watson 1966, 1967). Several projectile points in the level 13 assemblage were labeled level 13, but a few were labeled 13a and the rest labeled 13c. Only those labeled 13c (n=6) have been used in this analysis (Figure 4.3). This was done because the stratigraphic context of the 13c points was easier to determine than those from the rest of level 13 assemblage based on field notes and stratigraphic profiles (Kehoe 1965; Watson 1966, 1967). The assemblage will be referred to as Walter Felt 13c in the remainder of this analysis.

Another layer of yellow clay separates level 15a from level 13c (Kehoe 1965, Watson 1966, 1967). Level 15a (Figure 4.4) is interpreted as a Late Pelican Lake (Danker Shouldered) assemblage (Kehoe 1974:111) and is thought to be intermediate between Besant and Pelican Lake. Peck (2011) considers this level to be representative of his Bracken Phase. Only ten (10) projectile points were considered complete enough for analysis and henceforth will be referred to as Walter Felt 15a. Occupation level 15b is dated at 2430±90 (S-279) (Kehoe 1974, CARD 2013). Kehoe describes three (3) points associated with this level as Sandy Creek and assigns the occupation to Sandy Creek. However, the only points that Kehoe (1974:107) refers to that could be located were fragments. The only point that was obtained in those, available for study appeared closer to Dyck and Morlan's Outlook style (1995) than to Sandy Creek. The projectile point is straight based, with narrow "u" shaped notches, placed low on the margin. This point was left out of the analysis as it is unknown if the point was considered intrusive or if it did originate in the level as its style is very different to typical Sandy Creek projectile points. The final level excavated at the Walter Felt site is Level 15d (Figure 4.5). This level comprised Pelican Lake occupation. No date is associated with this level, but like the Mortlach Site, it is older than the overlaying Sandy Creek occupation. The point style of these projectile points is considered by Kehoe (1974) and Peck (2011) to be the earlier classic variety of Pelican Lake points and therefore, the complete points (n=3) from this level will be added to the Pelican Lake composite group.

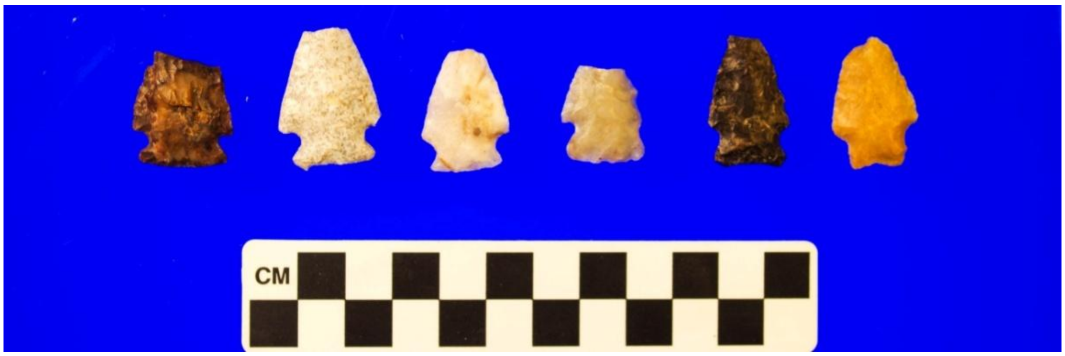

Figure 4.3 Walter Felt Site Level 13c Projectile Points.

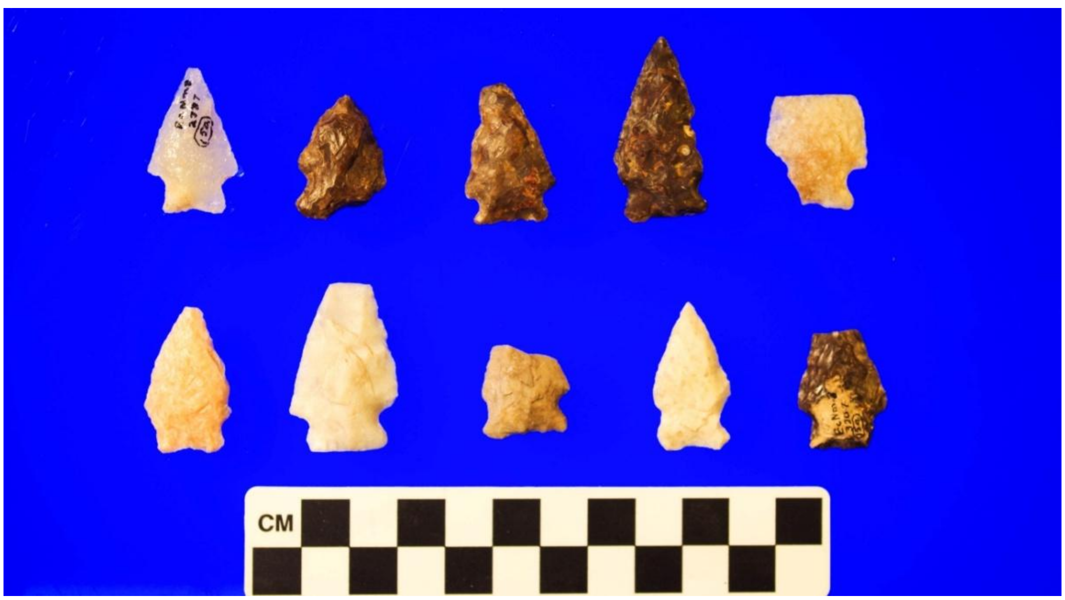

Figure 4.4 Walter Felt Site Level 15a Projectile Points.

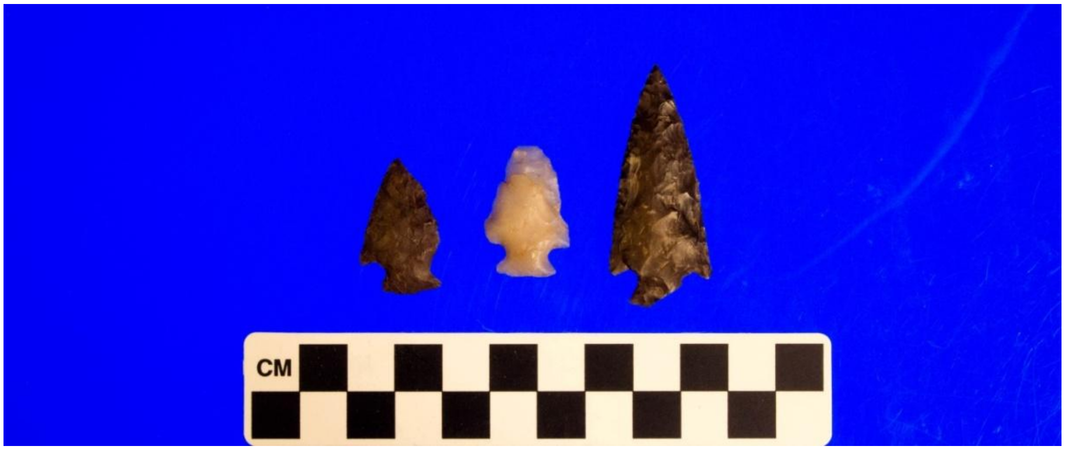

Figure 4.5 Walter Felt Site Level 15d Projectile Points.

4.4 The Sjovold Site (EiNs-4)

The Sjovold Site is a multi-component campsite situated on the bank of the South Saskatchewan River in south central Saskatchewan, south of the town of Outlook. Excavations were undertaken by the Royal Saskatchewan Museum (then Saskatchewan Museum of Natural History) under the direction of Ian Dyck in 1979 and 1980 (Dyck and Morlan 1995). The site is comprised of twenty-one (21) buried components. The projectile points from levels XI, XII, and XIV are utilized in this thesis. Dyck and Morlan (1995) proposed that they represent the major three point styles that appear during the Besant Phase, they are kept separate in this study to test this hypothesis. The projectile points (n=2) from layer XI (Figure 4.6 top row) are the two referred to as Bratton by Dyck and Morlan (1995). This level dates from 2500 to 2200 BP. This point style is thought to represent the convex based Besant points (Dyck and Morlan 1995:378-379). The authors (Dyck and Morlan 1995) rejected both dates from this level and decided to bracket it by the dates from the levels above and below. Dyck and Morlan note that this particular point style is common in both Besant and Pelican Lake assemblages. The Sandy Creek level (XII) is represented by one (n=1) intact point and a date of 2355±105 (S-2059) (Dyck and Morlan 1995; CARD 2013). The single complete Sandy Creek projectile point was unavailable for study and the image was digitized out of the Sjovold Site manuscript. Sandy Creek projectile points are thought to represent the concave based varieties of Besant points (Dyck and Morlan 1995:398). The final level examined from the Sjovold Site for this thesis is level XIV. The projectile points from this level are a small side-notched variety considered Outlook side-notched points (n=5) (Dyck and Morlan 1995) and the level has been dated to 2500±85 (S-2060) (CARD

2013). These points (Figure 4.6 bottom row) are thought of representing the straight based Besant points (Dyck and Morlan 1995:437). Unlike the Sandy Creek point that was added to a composite group, these points will be kept as their own entity to test whether other straight based Besant points are similar enough to be considered "Outlook" points.

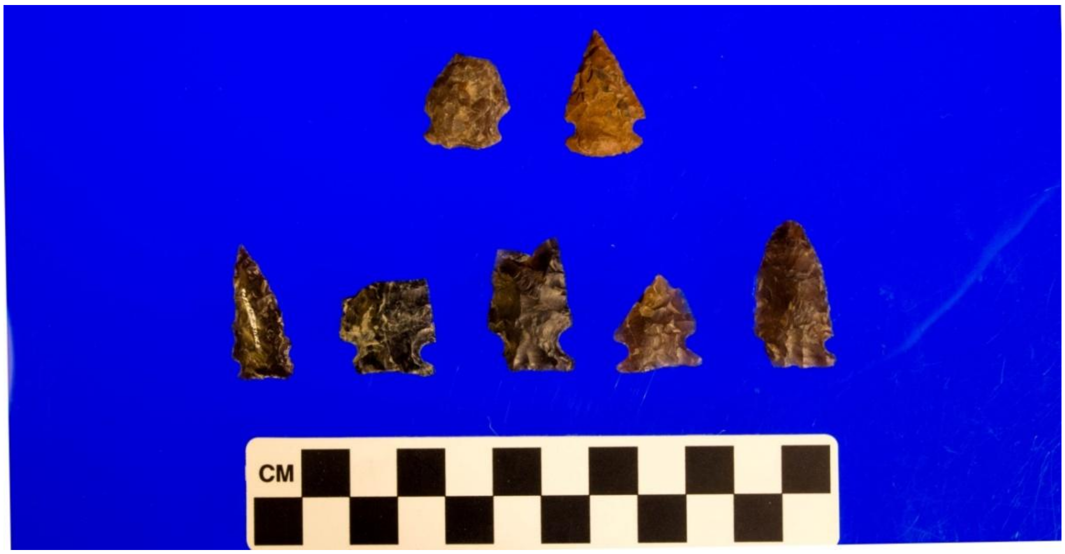

Figure 4.6 Sjovold Site Projectile Points.
Top Row; Bratton Level 11, Bottom Row; Outlook Level 14.

4.5 The Crane Site (DiMv-93)

The Crane Site is a now inundated site in the former Souris River valley in southeastern Saskatchewan, west of the community of Midale. The site is a multi-component buried campsite discovered in 1986 and excavated in one form or another from 1987 to 1990. It was located on a small portion of river bank between the Souris River and its associated valley wall (Gibson and McKeand 2010). The site contained at least twenty (20) occupational levels of which only the first eleven (11) were excavated due to project constraints (Gibson and McKeand 2010). These first eleven (11) occupations date from the historic period to just before 1970±70 B.P. (S-3212 Occupation X at 135cm below surface, level 26) (CARD 2013) . The oldest date recovered is associated with a Pelican Lake point (3250±95, S-2969) and is from a depth of 270cm (Gibson and McKeand 2010:16; CARD 2013). This point was from a unit excavated along the creek bank during the initial survey (Gibson and McKeand 2010).

For the projectile point analysis, I focused on those points from Occupation X (levels 25-

28) and the dated point from the river bank unit (hence forth referred to as level 54). The projectile points from Occupation X are described as late Pelican Lake or aberrant-appearing Besant (Gibson and McKeand 2010:92). Nine (9) points were intact enough from this level to be used in the study and they will be referred to as "Crane X" (Figure 4.7). No effort was made to split up the point assemblage between the aberrant Besant points and the Pelican Lake points from this level, instead they are treated as a possibly intermediate assemblage. The projectile point from level 54 (Figure 4.7 bottom row far left) is described as Pelican Lake (Gibson and McKeand 2010:16) and is added to the Pelican Lake composite group described in the previous chapter.

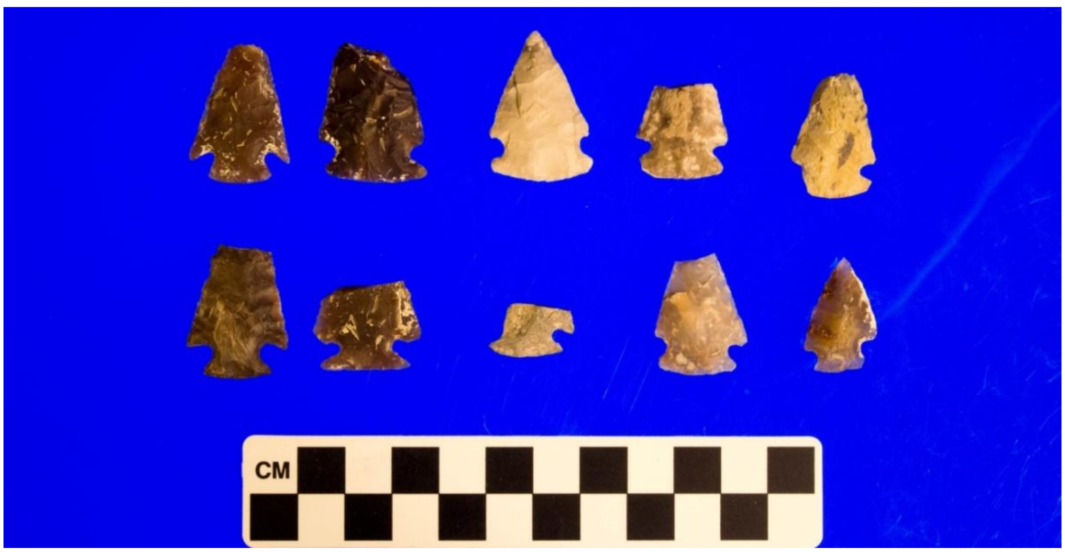

Figure 4.7 Crane Site Projectile Points.
Occupation Level X and Level 54 Projectile Point (bottom far left).

4.6 The Rocky Island (FaNp-7)

The Rocky Island site is a single occupation camp/hide processing site located in the South Saskatchewan River valley within the city of Saskatoon, in south-central Saskatchewan. The site was excavated both in 1983 as part of the Saskatoon Perimeter Archaeological Resource Assessment and again in 1995 (Walker 1983; Friend-Heath 1995). The site contains nine (9) hearths in three parallel lines one of which is associated with a post hole (Walker 1983; Frary 2009:135).

The site was originally considered to be a late side-notch component (Walker 1983) but when it returned a date of 2475±120 (S-2437) (CARD 2013) the affiliation was reconsidered. The projectile points recovered (n=2) (Figure 4.8) do not fit well within the Terminal Middle Period cultural dichotomy of the Plains that formed the basic question that drove this thesis. Previous researchers have thought the site may be associated with the Besant (Dyck and Morlan 1995), “Unnamed/Outlook” or Bratton Complex (Frary 2009; Morlan 1994), or possibly Pelican Lake (Friend-Heath 1995). The point assemblage is referred to as Rocky Island in the remainder of this thesis.

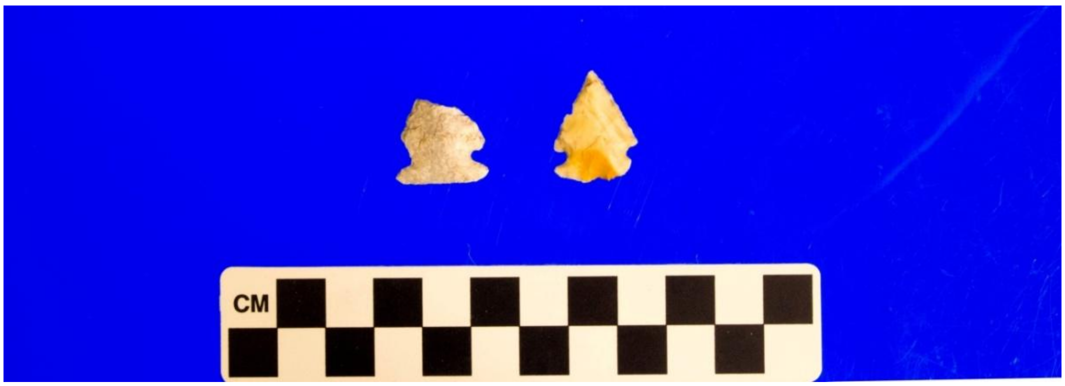

Figure 4.8 Rocky Island Site Projectile Points.

4.7 The Smyth Site (DjPm-116)

The Smyth site is a kill site located in the Oldman reservoir along what used to be Crowsnest River in southwestern Alberta near the community of Pincher Creek and is now inundated (Landals 2009). It was the largest kill site excavated as part of the Oldman River Dam Killsite Mitigation Program in 1988 through 1990 (Landals 2009). The site represents multiple uses through the precontact time period and may contain the remains of over 1000 bison. The site was excavated in several blocks linked by trenches. The cultural levels used in this projectile point analysis have been interpreted as exhibiting cultural continuity despite the very plausible multiple use events (Landals 2009:132).

In the Northeast portion of the site, Block “D” Cultural Unit 8 dates to 2,220±110 BP (AECV-344 C), in Block “M” Cultural Unit 82 dates to 2,630±120 BP (AECV-1229 C), in Block “E” Cultural Unit 16 dates to 2,290±100 BP (AECV-867 C), and in Block “H” Cultural Unit 85 dates to 2,510±90 BP (AECV-1231 C) (Landals 2009; CARD 2013). In Block ‘A”

Cultural Units 34 and 35 are not dated, but exist in the same stratigraphic layer that was traced to the other dated levels (Landals 2009). In the Northwestern portion of the site Block “C” Cultural Unit 38 dates to 2650±140 BP (AECV-868 C), in Block “B/K” Cultural units 32/69 date to 2,750±160 BP (AECV-1228 C), and in Block “L” Cultural unit 71 dates to 2,560±110 BP (AECV-1236 C) (Landals 2009; CARD 2013). A total of 140 projectile points were recovered from the site; of these, only thirty-eight (38) were used in this analysis. These points were considered to belong to the Pelican Lake Phase (Landals 2006:50) though Landals (2009:132) notes that some of the assemblage would better fit in with Besant or Sandy Creek. However, Peck (2011) considers them part of the Bracken Complex on the basis of point morphology and their use at a kill site. The assemblage is referred to as “Smyth” from this point onward to allow for testing of both hypotheses. The projectile points were digitized from of the images in Landals’ (2009) manuscript as the images were of good quality and were scaled.

4.8 The Fitzgerald Site (ElNp-8)

The Fitzgerald site is believed to represent a single event bison kill site located in the Moose Woods Sand Hills in south-central Saskatchewan, southeast of Saskatoon (Hjermstad 1996). The site represents an extensive bison pound and processing area in which a minimum of forty-nine (49) bison upwards to a possible 800 bison were believed to have met their demise (Hjermstad 1996). The site was excavated in 1992 and 1993 and four (4) radiocarbon dates were obtained, of which two (2) were from the processing area; 1490±90 BP (Beta 69005), 1270±140 BP (S-3546), and two (2) were from the kill site: 1340±60 BP (Beta 69004), 1160±170 BP (S-3547) (Hjermstad 1996). Hjermstad (1996) assigns the site to the Besant complex based on projectile point morphology, the high frequencies of Knife River Flint, and his averaged uncalibrated date of 1362±45 BP. A large assemblage of projectile points (n=143) was recovered from this site (Hjermstad 1996:47), of which sixty-eight (68) were complete, near complete, or bases (Hjermstad 1996:47). Of those, only thirty-seven (37) points were used in this analysis as the remainder were too fragmentary or represented flake points. In his analysis of the projectile points, Hjermstad (1996) saw no reason to split up the “Bratton” and “Outlook” point styles instead he suggested they be classified as “Besant Side-Notched” projectile points. For the purpose of this thesis, the assemblage (Figures 4.9, 4.10, and 4.11) will be referred to as

“Fitzgerald” so as not to confuse them with the Besant composite group from the Mortlach site.

Figure 4.9 Fitzgerald Site Projectile Points (a).

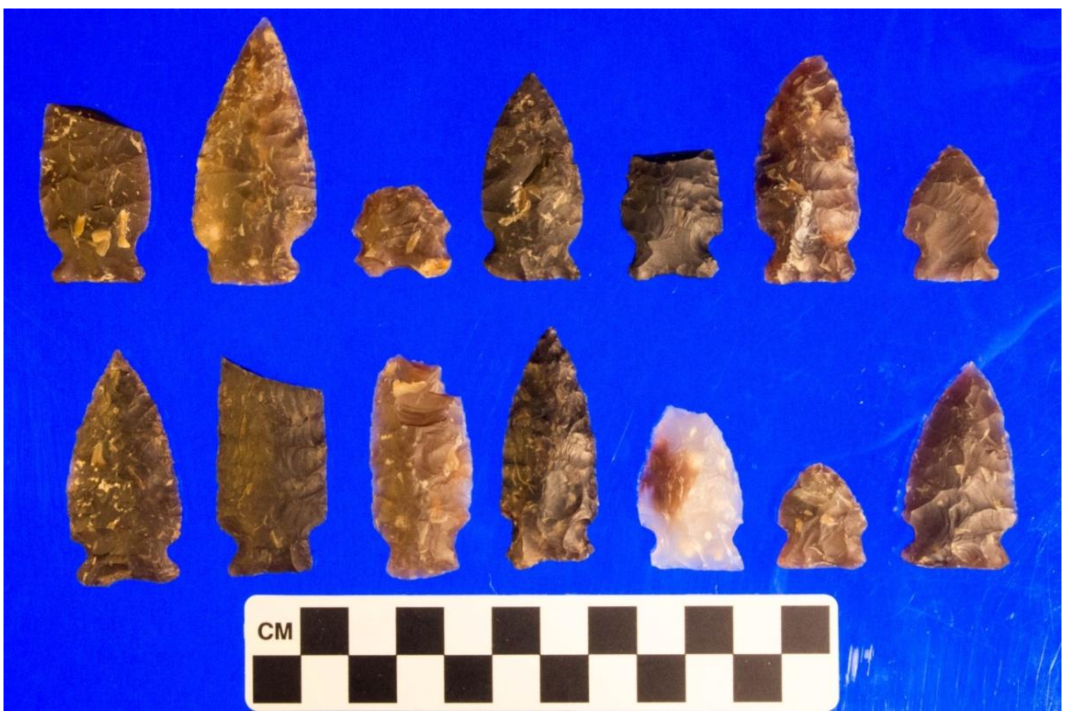

Figure 4.10 Fitzgerald Site Projectile Points (b).

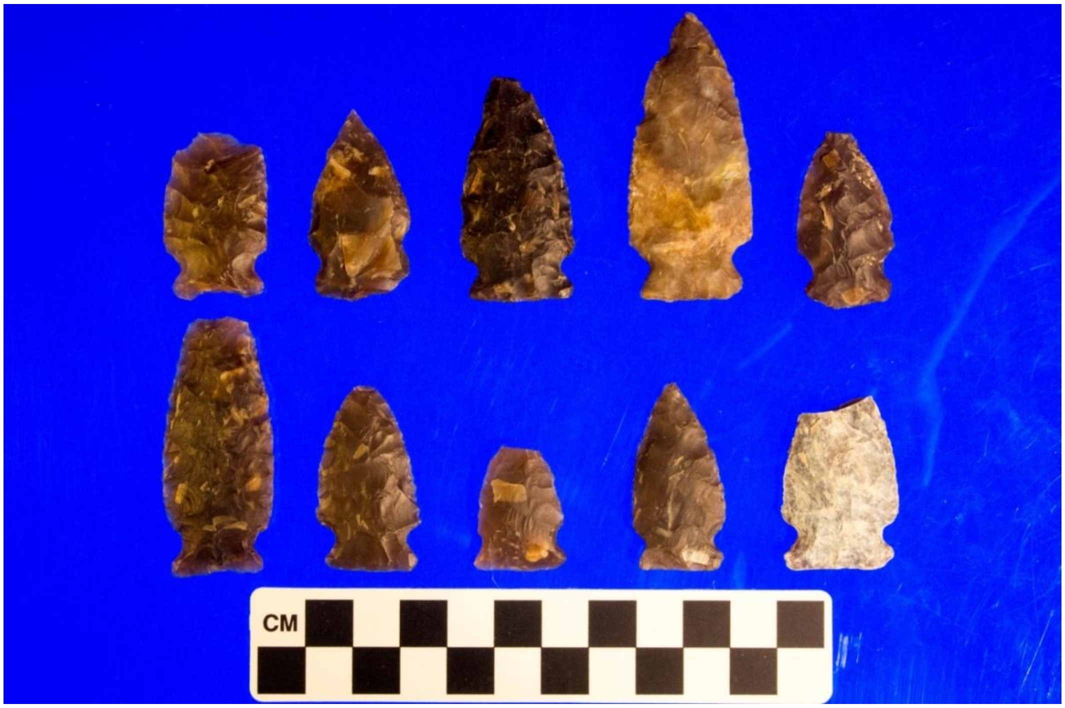

Figure 4.11 Fitzgerald Site Projectile Points (c).

4.9 The Fincastle Site (DlOx-5)

The Fincastle Site is a bison kill located in a series of sand hills east of Lethbridge in southern Alberta (Varsakis 2006). The site is seen as a single use bison kill that utilized a pound type structure to capture and dispatch bison. Varsakis (2006) originally considered the site to represent an early Sonota occupation on the Alberta Plains. This affiliation was deduced from material excavated in 2003, 2004, and 2006 on the basis of point style, the use of bone uprights, and the high percentage of Knife River Flint points (Varsakis 2006). Two (2) dates were returned from the Fincastle on the occupational level in association with an articulated bison vertebra and a bone upright of 2540±50 (Beta-201909) and 2490±60 (Beta-201910) respectively (Varsakis 2006:110&111). Peck (2011) proposes that the Fincastle site is associated with the Outlook Complex based on his re-evaluation of precontact material from Alberta and adjacent regions. The name for this complex is based on Dyck and Morlan's (1995) Outlook projectile point style from the Sjovold site which occurs at a similar time on the Saskatchewan Plains. They recovered seventy-two (72) projectile points and fragments thereof (Varsakis 2006:99) of which only forty-one (41) were deemed complete enough for analysis in this thesis. The projectile points were digitized off of images presented by Varsakis (2006). The assemblage will be referred to as

Fincastle to allow testing of both Varsakis' (2006) and Peck's (2011) theories on this assemblage.

Chapter 5

Results

In the previous chapters the assemblages and methods of analysis were introduced. The assemblages were subjected to Canonical Variate Analysis (CVA), Discriminate Function Analysis (DFA), UPGAMA (Unweighted Pair Group Method and Arithmetric Mean) Cluster Analysis and Arrow/Dart related metric testing. The results of these approaches are presented in this chapter. For ease of reading the results in their entirety are contained in several appendices each pertaining to a particular research method and associated results. Appendix A contains the Results of the Canonical Variate Analysis on assemblages. Appendix B is the Results of the Discriminate Function Analysis on assemblages. Appendix C is the Results of UPGAMA Cluster Analysis on assemblages. Lastly Appendix D is the Results of Arrow vs Dart Metric Testing on assemblages. This chapter will make several references to the Appendices where applicable. However, the results will be discussed briefly in this chapter to provide a basic understanding of the trends represented.

5.1 Canonical Variate Analysis (CVA)

The CVA resulted in several distinct (given the small sample size) clusters of the data along Canonical Variate 1 (CV1) and Canonical Variate 2 (CV2) (Figure 5.1, 5.2, 5.3). The amount of variance associated with each CV can be found in Table A.2 in Appendix A. As is standard with most reporting on Principle Component and Canonical Variate Analysis only the CV's explaining a variance of at least 5% will be explained and graphed (Zelditch et al 2004:167-168). The results of these graphs can be seen in Appendix A (CV1 to CV4). The graphs in Appendix A are of three (3) major types. The first shows the location of the observations (individual projectile points) plotted against the CV's represented in the graph with colour differences representing different assemblages (example Figure 5.1). The second shows the same observations with 95% confidence ellipses around the mean (example Figure 5.2). The third and final graph constructed from the CVA data in Appendix A shows the group means for the assemblages. The larger the ellipse the larger the variance within the assemblage (also usually linked to sample size) (example figure 5.3). The confidence ellipses are not shown for the Bratton and Rocky Island assemblages as a group mean could not be determined on the basis of the small sample size. The two outlines on each axis represent the shape change along the CV. Variance explained by the CV is also located along the axis it is associated with.

Canonical Variate 1 represents change of the base along the continuum from basal concavity to basal convexity. This CV explains 69.4% of the change associated with the study suggesting that basal shape, and to a lesser degree neck width, play a very distinct role in style determination in these assemblages. The change represented by CV2 is the width of the base and 14.1% of the variance within the study. Canonical Variate 3 represents 8.9% of the variance in the study and is associated with orientation of the notch. The last CV graphed and discussed in this study is CV4 representing 5.4% of the variance. It is associated with changes in the location of the narrowest part of the neck longitudinally and to a lesser degree basal edge height. Refer to Appendix A for in depth examples of these CV's and associated graphs. The graphs shown below portray the distribution of projectile points along CV1 and CV2 which accounts for 83.532% of the variance observed in the study. A trending pattern can be seen here in these graphs that continues through the data presented in Appendix A.

As the CVA process in rudimentary terms can be seen as multi-group DFA, general trends in similarities and differences can be observed within it. A definite clustering can be seen between related or supposedly related assemblages. This is best seen in graphs with CV1 and the assemblages associated confidence ellipses portrayed on them (Figure 5.2, 5.3 in this chapter). The "Pelican Lake" composite assemblage separates itself substantially from the "Besant" like assemblages. The Besant composite and other "Besant" like assemblages (Fincastle, Fitzgerald, Sandy Creek, Walter Felt 13c and 15a) cluster on the opposite end of the spectrum. This leaves several assemblages (Bratton, Crane X, Outlook, Rocky Island, and Smyth) falling in between those two clusters and forming a rough group of "Intermediate" assemblages in relation to shape. This is further examined by the Cluster Analysis presented later in this chapter.

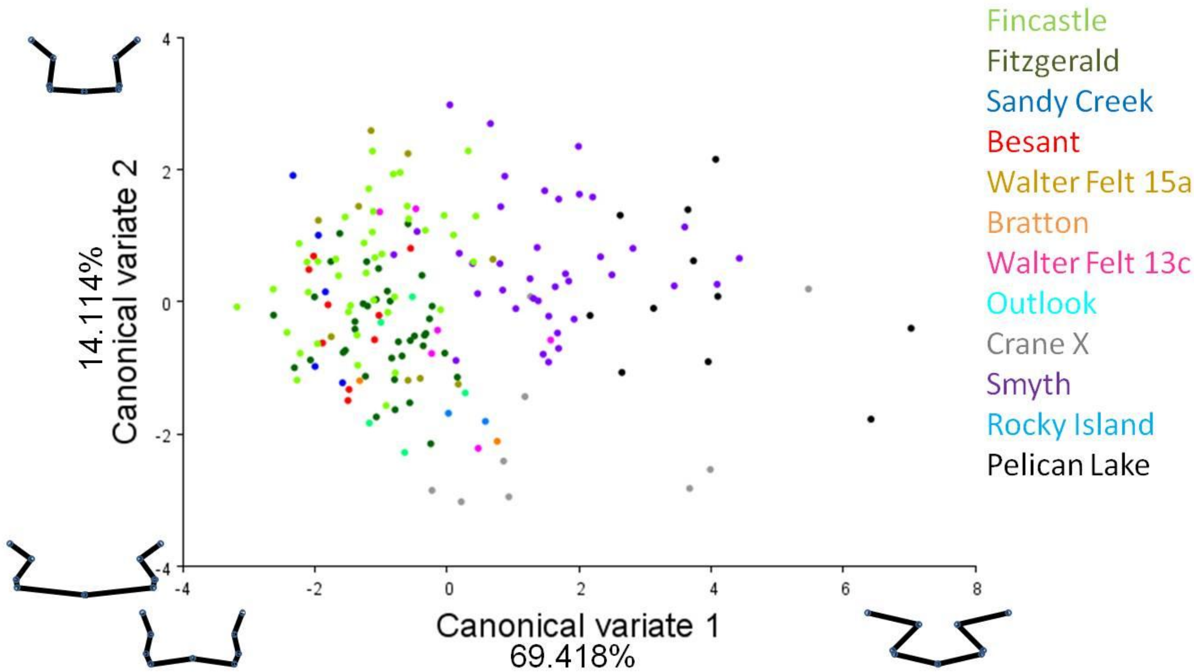

Figure 5.1 Graph of CV1 plotted against CV2.

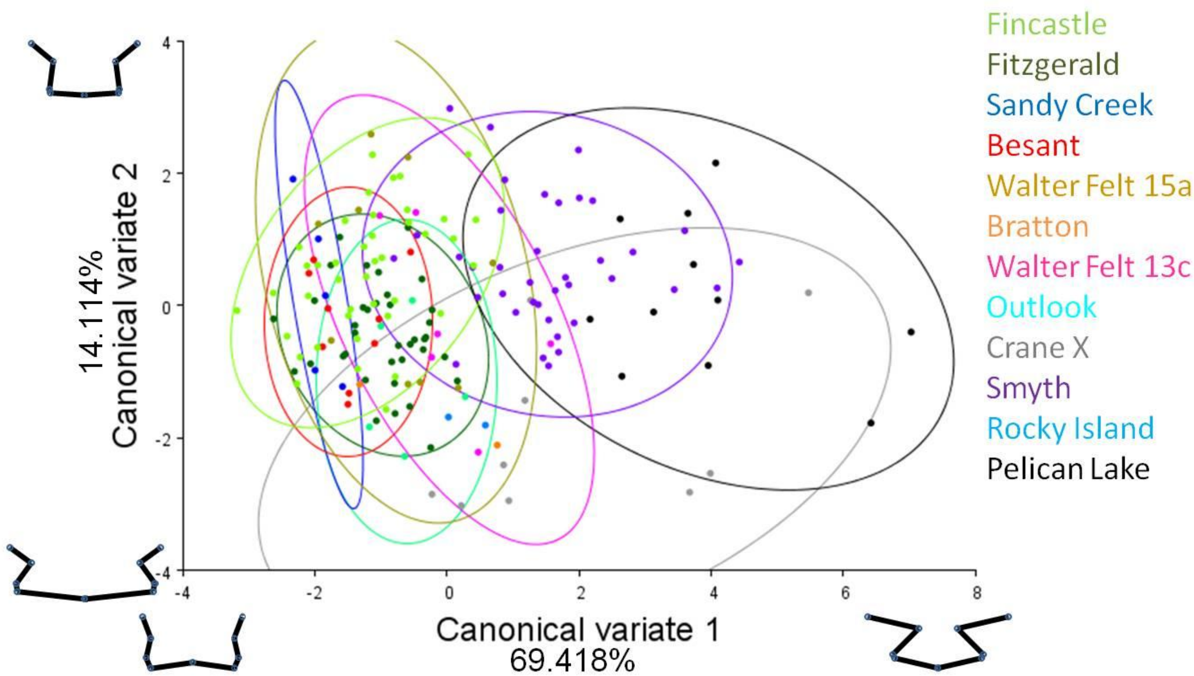

Figure 5.2 Graph of CV1 plotted against CV2 with 95% confidence ellipses.

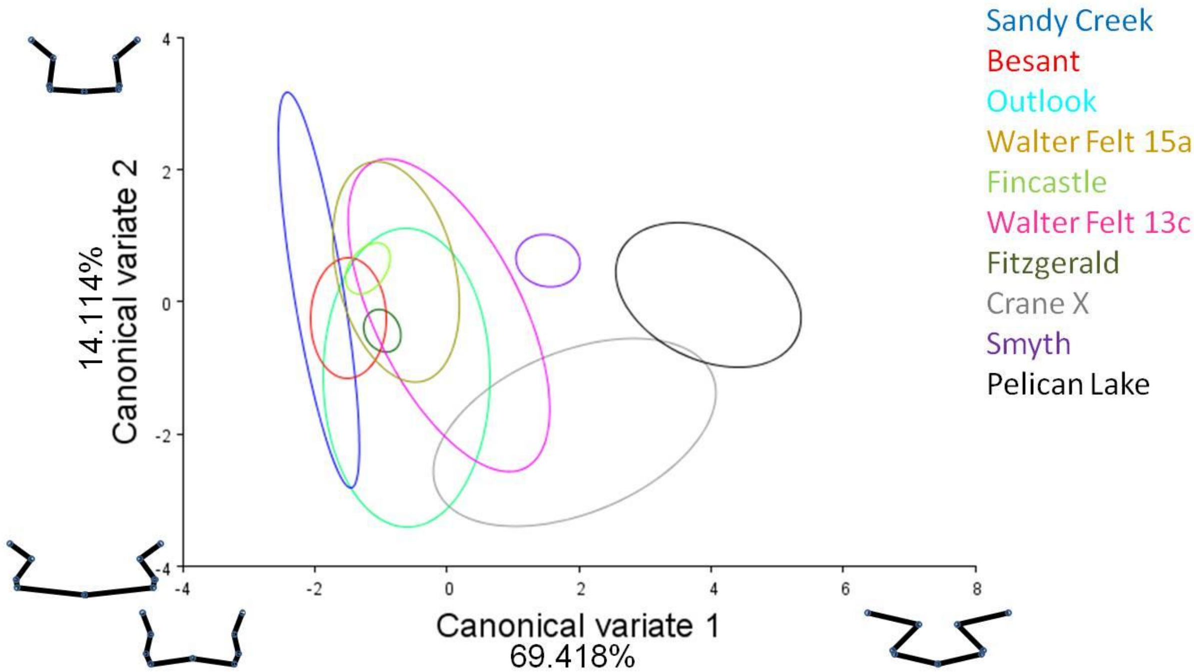

Figure 5.3 Graph of CV1 plotted against CV2 with ellipses around the group means.

This clustering is also seen in the distances and associated p-values presented in this chapter and Appendix A. The CVA process created four (4) data tables that are shown in Appendix A. The closer the numbers are in the Mahalanobis and Procrustes distances (Appendix A) the closer the two group means are in morphology. The p-values for the distances are also shown here (Tables 5.1, 5.2). The permutation tests that the p-values were derived from CVA to test the null hypothesis of variance and, therefore, the significance of the distances. This allows for an idea of the uniqueness of the assemblages and denotes the chance that the assemblages are just randomly or subjectively divided. Again "Pelican Lake" is seen as the most dissimilar to the other assemblages, which is not surprising as it represents a point style that is very morphologically different from most other assemblages (the exception being the Smyth site assemblage). The "Besant" type assemblages (Besant, Fitzgerald, Fincastle, Sandy Creek and the two Walter Felt assemblages) tend to relate well to each other (showing levels of indistinguishable morphology within the 95% confidence setting of the null hypothesis). Some of the "Intermediate" type assemblages relate well to each other (Rocky Island to Outlook, Rocky Island to Bratton to Crane X), but also show some very obvious overlap between themselves and the “types” that flank them, cementing their place as “Intermediate”. The one that seems to diverge from this trend is the Smyth assemblage as it sits perched closer to the “Pelican Lake” assemblage. This will be explored later in this chapter.

Table 5.1 P-values from permutation tests for Mahalanobis distances among groups.

Assemblage	Besant	Bratton	Crane X	Fincastle	Fitzgerald	Outlook	Pelican Lake	Rocky Island	Sandy Creek	Smyth	Walter Felt 13c	Walter Felt 15a
Besant	1	0.0564	<.0001	0.0113	0.2497	0.0014	0.0001	0.0653	0.3097	<.0001	0.3088	0.186
Bratton	0.0564	1	0.1877	0.006	0.2089	0.005	0.0235	<.0001	0.0423	0.0018	0.4103	0.037
Crane X	<.0001	0.1877	1	<.0001	<.0001	0.0012	0.0008	0.1661	0.0001	<.0001	0.0154	<.0001
Fincastle	0.0113	0.006	<.0001	1	<.0001	<.0001	<.0001	0.0001	0.003	<.0001	0.0142	0.1822
Fitzgerald	0.2497	0.2089	<.0001	<.0001	1	0.0006	<.0001	0.0281	0.004	<.0001	0.3947	0.0694
Outlook	0.0014	0.005	0.0012	<.0001	0.0006	1	<.0001	0.3973	0.0604	<.0001	0.036	0.0289
P. Lake	0.0001	0.0235	0.0008	<.0001	<.0001	<.0001	1	0.0231	<.0001	<.0001	0.0001	<.0001
R. Island	0.0653	<.0001	0.1661	0.0001	0.0281	0.3973	0.0231	1	0.1893	0.0071	0.394	0.0148
S. Creek	0.3097	0.0423	0.0001	0.003	0.004	0.0604	<.0001	0.1893	1	<.0001	0.0629	0.1712
Smyth	<.0001	0.0018	<.0001	<.0001	<.0001	<.0001	<.0001	0.0071	<.0001	1	0.0221	<.0001
WF 13c	0.3088	0.4103	0.0154	0.0142	0.3947	0.036	0.0001	0.394	0.0629	0.0221	1	0.6159
WF 15a	0.186	0.037	<.0001	0.1822	0.0694	0.0289	<.0001	0.0148	0.1712	<.0001	0.6159	1

Table 5.2 P-values from permutation tests for Procrustes distances among groups.

Assemblage	Besant	Bratton	Crane X	Fincastle	Fitzgerald	Outlook	Pelican Lake	Rocky Island	Sandy Creek	Smyth	Walter Felt 13c	Walter Felt 15a
Besant	1	0.0175	<.0001	0.0219	0.0469	0.0074	0.0001	0.0574	0.1719	<.0001	0.234	0.2894
Bratton	0.0175	1	0.4275	0.0012	0.0854	0.0139	0.0072	0.3428	0.0462	<.0001	0.2907	0.0386
Crane X	<.0001	0.4275	1	<.0001	<.0001	0.0004	0.0001	0.094	0.0001	<.0001	0.0165	0.0008
Fincastle	0.0219	0.0012	<.0001	1	<.0001	0.0015	<.0001	0.0108	0.0025	<.0001	0.0831	0.4347
Fitzgerald	0.0469	0.0854	<.0001	<.0001	1	0.0031	<.0001	0.1594	0.0006	<.0001	0.4162	0.0351
Outlook	0.0074	0.0139	0.0004	0.0015	0.0031	1	<.0001	0.4903	0.0773	<.0001	0.1611	0.1403
P. Lake	0.0001	0.0072	0.0001	<.0001	<.0001	<.0001	1	0.0099	<.0001	<.0001	0.0001	<.0001
R. Island	0.0574	0.3428	0.094	0.0108	0.1594	0.4903	0.0099	1	0.1826	0.0183	0.5755	0.2992
S. Creek	0.1719	0.0462	0.0001	0.0025	0.0006	0.0773	<.0001	0.1826	1	<.0001	0.1072	0.2193
Smyth	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0183	<.0001	1	0.0623	0.0004
WF 13c	0.234	0.2907	0.0165	0.0831	0.4162	0.1611	0.0001	0.5755	0.1072	0.0623	1	0.6095
WF 15a	0.2894	0.0386	0.0008	0.4347	0.0351	0.1403	<.0001	0.2992	0.2193	0.0004	0.6095	1

5.2 Discriminate Function Analysis (DFA)

The results of the DFA are largely presented in Appendix B. As mentioned in Chapter Three the focus of reporting will be on the cross validation results as they better represent the equation's capability to distinguish between assemblages (Kovarovic et al 2011, Strauss 2010). A summary of the DFA's cross validation classification rates per DFA equation are shown in Table 5.3. These results show the equation's overall accuracy in separating the tested point styles, but can be skewed by comparing large to small assemblages and the highly variable nature of some assemblages. As a result of this, the results of the DFA's cross validation rates for each assemblage in each DFA are shown in Table 5.4. In this table, the columns represent the classification rate for each assemblage while the rows represents the classification of other assemblage in the DFA equation that the assemblage was compared to. To interpret Table 5.4, for example if one looks at the Pelican Lake column, firstly you see the number of points represented in that group, in this case eleven. Then as you descend the table you will see how correctly the group was classified individually in relation to the other groups it was tested against. From this you can see it was correctly classified very successfully in almost all cases with the exception of when it was tested against the Smyth assemblage.

Table 5.3 Cross Validation Rates (per DFA comparison).

Assemblage	Besant	Bratton	Crane X	Fincastle	Fitzgerald	Outlook	Pelican Lake	Rocky Island	Sandy Creek	Smyth	Walter Felt 13c	Walter Felt 15a
Besant	x	63.9%	88.9%	64.4%	62.9%	84.4%	94.4%	33.3%	74.4%	89.2%	66.7%	61.1%
Bratton	63.9%	x	52.8%	71.3%	40.5%	65.0%	40.9%	25.0%	80.0%	73.7%	50.0%	38.9%
Crane X	88.9%	52.8%	x	94.4%	93.1%	88.9%	74.2%	27.8%	90.0%	86.3%	63.9%	72.2%
Fincastle	64.4%	71.3%	94.4%	x	72.9%	98.8%	100%	75.0%	75.1%	89.8%	58.1%	60.7%
Fitzgerald	62.9%	40.5%	93.1%	72.9%	x	85.9%	100%	70.9%	80.5%	93.4%	53.2%	54.7%
Outlook	84.4%	65.0%	88.9%	98.8%	85.9%	X	100%	20.0%	50.0%	84.7%	63.3%	58.9%
P. Lake	94.4%	40.9%	74.2%	100%	100%	100%	x	50.0%	100%	75.2%	82.6%	95.5%
R. Island	33.3%	25.0%	27.8%	75.0%	70.9%	20.0%	50.0%	x	60.0%	71.1%	75.0%	50.0%
S. Creek	74.4%	80.0%	90.0%	75.1%	80.5%	50.0%	100%	60.0%	x	87.4%	73.3%	78.9%
Smyth	89.2%	73.7%	86.3%	89.8%	93.4%	84.7%	75.2%	71.%	87.4%	x	61.8%	94.7%
WF 13c	66.7%	50.0%	63.9%	58.1%	53.2%	63.3%	82.6%	75.0%	73.3%	61.8%	x	55.6%
WF 15a	61.1%	38.9%	72.2%	60.7%	54.7%	58.9%	95.5%	50.0%	78.9%	94.7%	55.6%	X

Table 5.4 Cross Validation Rates (per assemblage).

Assemblage	Besant	Bratton	Crane X	Fincastle	Fitzgerald	Outlook	Pelican Lake	Rocky Island	Sandy Creek	Smyth	Walter Felt 13c	Walter Felt 15a
Total in Assemblage	9	2	9	41	37	5	11	2	5	38	6	9
vs Besant	x	50.0%	88.9%	73.2%	70.3%	80.0%	100%	0.0%	60.0%	89.5%	66.7%	55.6%
vs Bratton	77.8%	X	55.6%	92.7%	81.1%	80.0%	81.8%	0.0%	60.0%	97.4%	50.0%	77.8%
vs Crane X	88.9%	50.0%	x	100%	97.3%	100%	81.8%	0.0%	80.0%	94.7%	50.0%	66.7%
vs Fin	55.6%	50.0%	88.9%	x	70.3%	100%	100%	50.0%	60.0%	86.8%	33.3%	55.6%
vs Fitz	55.6%	0.0%	88.9%	75.6%	x	80.0%	100%	50.0%	80.0%	89.5%	33.3%	44.4%
vs Outlook	88.9%	50.0%	77.8%	97.6%	91.9%	X	100%	0.0%	60.0%	89.5%	66.7%	77.8%
vs P. Lake	88.9%	0.0%	66.7%	100%	100%	100%	X	0.0%	100%	86.8%	83.3%	100%
vs R. Island	66.7%	50.0%	55.6%	100.0%	91.9%	40.0%	100%	x	20.0%	92.1%	100.0%	100.0%
vs S. Creek	88.9%	100.0%	100.0%	90.2%	81.1%	40.0%	100%	100%	x	94.7%	66.7%	77.8%
vs Smyth	88.9%	50.0%	77.8%	92.7%	97.3%	80.0%	63.6%	50.0%	80.0%	x	50.0%	100.0%
vs WF 13c	66.7%	50.0%	77.8%	82.9%	73.0%	60.0%	81.8%	50.0%	80.0%	73.7%	x	77.8%
vs WF 15a	66.7%	0.0%	77.8%	65.9%	64.9%	40.0%	90.9%	0.0%	80.0%	89.5%	33.3%	X

Similar trends in the data to those that resulted from the CVA can be seen in here in the DFA data. The equations pertaining to the "Pelican Lake" assemblage was the most clearly defined assemblage differentiating them from the other assemblages. While the groups in the "Besant" assemblages showed interlinking morphology mimicking the CVA results suggesting minor internal divides but overall similarity between the assemblages. The assemblages on the fringes of the "Intermediate" and "Besant" types, particularly those with earlier dates, were more difficult to distinguish as one may expect.

The classification rates tend to be lower for the some of the older "Besant" assemblages (Walter Felt 13c, 15a, and Sandy Creek composite group) and some of the "Intermediate" assemblages (Rocky Island, Outlook, Bratton, and Crane X). This can be explained in one of two ways. If one takes the CVA data into effect it can be explained as small sample size (demonstrated in Table 5.4) and high variability in those samples (shown as large mean ellipses Figure 5.3). The homogeneity of the projectile points from kill site assemblages (Fincastle, Fitzgerald, and Smyth) may be a result of a smaller group of flintknappers or stricter norms than what would be responsible for the points from camp/habitation sites (Bamforth 1991). This idea is countered to a certain extent by the "Pelican Lake" assemblage which only slightly out numbers Walter Felt 15a, shows similar variability, yet retains the highest accuracy in relation to classification rates. This suggests that the previously mentioned older "Besant" and

“Intermediate” assemblages may be more closely related in terms of morphology and/or that examples of mixed “style” assemblages. This may again further support the idea of some form of “Intermediate” assemblages.

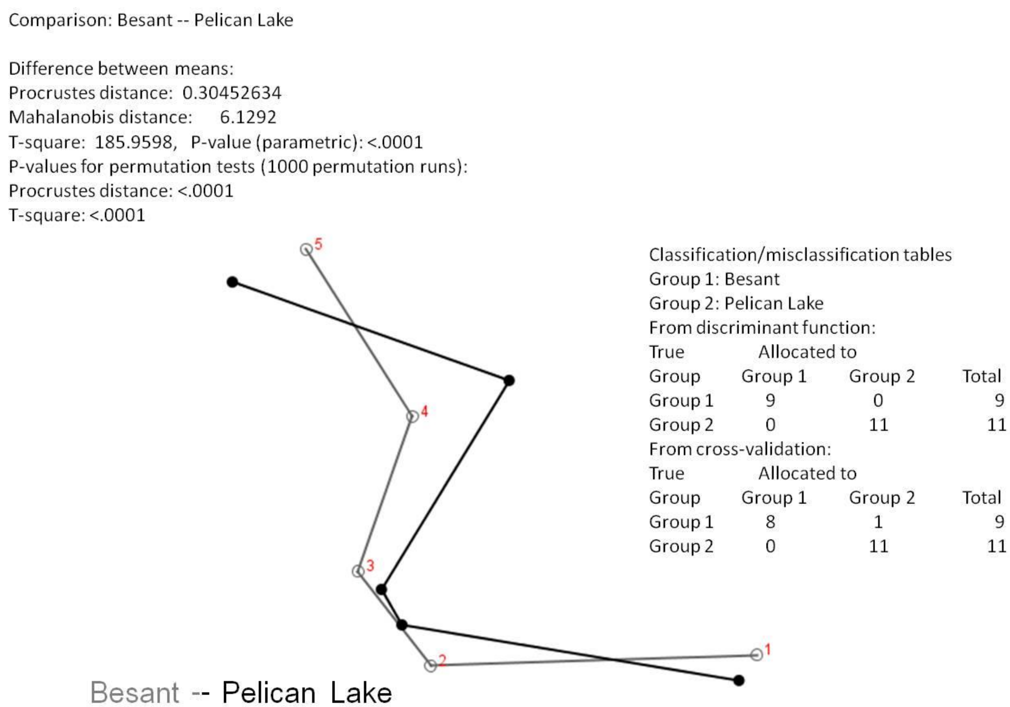

Figure 5.4 DFA Results of Besant compared to Pelican Lake.

The above Figure (5.4) is a representation of the majority of data presented in Appendix B. The image has three (3) major portions. The first portion in the top left shows the Procrustes and Mahalanobis distances, permutation test scores, and T² results. The second portion in the more or less the middle is the shape comparisons between the average Procrustes shape for each assemblage. Group 1 is the lighter coloured wireframe shape, while group 2 is the darker coloured one. The third portion on the right side is the classification/misclassification table showing the results of the original DFA between the two (2) groups/assemblages and the cross-validation (leave one out) results. The results of the cross-validation are summarized in Tables 5.3 and 5.4 and their identical tables in Appendix B. One of these figures is generated for each possible pair wise comparison in the study (n=66), and are located in Appendix B.

This particular figure (5.4) shows the difference in shape between the Besant and Pelican Lake assemblages and how the landmark placement captured that difference. It also briefly illustrates the trend present with all DFA's relating to the Pelican Lake assemblages. There is a high degree of accuracy in separating out Pelican Lake points from other projectile points. Pelican Lake points were correctly classified 90.9% of the time, while points from the Rocky Island assemblage were correctly classified 27.3% of the time (Table 5.5). The abysmal classification rates for the Bratton, Rocky Island, Walter Felt 13c, and to a lesser degree Sandy Creek are rooted in the small heterogeneous samples that they represent and possibly their placement in the culture chronology of the Northern Plains. The reverse is believed to be represented by the Fincastle and Fitzgerald assemblages as their numerical superiority may have created divisions were none may exist. This is evident if one looks at the shape differences in Figures B.3, B.4, and B.31, compared the differences in Figures B.1 and B.22 all in Appendix B.

Table 5.5 Overall Percentages of Correct Classification based on DFA.

Besant	Bratton	Crane X	Fincastle	Fitzgerald	Outlook	Pelican Lake	Rocky Island	Sandy Creek	Smyth	Walter Felt 13c	Walter Felt 15a
75.8%	40.9%	77.8%	88.2%	83.5%	72.7%	90.9%	27.3%	69.1%	89.5%	57.6%	75.8%

5.3 UPGAMA Cluster Analysis

This analysis was performed using the data derived from the CVA process. As mentioned in Chapter 3, the Mahalanobis and Procrustes distances and the data from their associated permutation tests (see Appendix A) were utilized. The comprehensive results of this analysis can be seen in Figure 5.5, and C.1 and C.2 in Appendix C. The expanded results are also shown in Appendix C, in which the shape change from one node (or branching point) to another node/assemblage is visually represented.

The diagrammatic representation of the CVA data represented by Figure 5.5 replicates the trends seen in the other data presented thus far. The clustering of the "Besant" and "Intermediate" type assemblages and their marked difference from "Pelican Lake" is evident. In Figure 5.5 the three (3) major "types" are evident and separate out from each other early in the cladogram. The "Pelican Lake" type is on the far left. The "Intermediate" type made up of the Outlook, Rocky Island, Crane X, Bratton and tentatively Smyth assemblages, is in the centre with the “Besant” type made up of the Sandy Creek, Walter Felt 13c, Besant, Fitzgerald, Fincastle, and Walter Felt 15a assemblages are shown on the right.

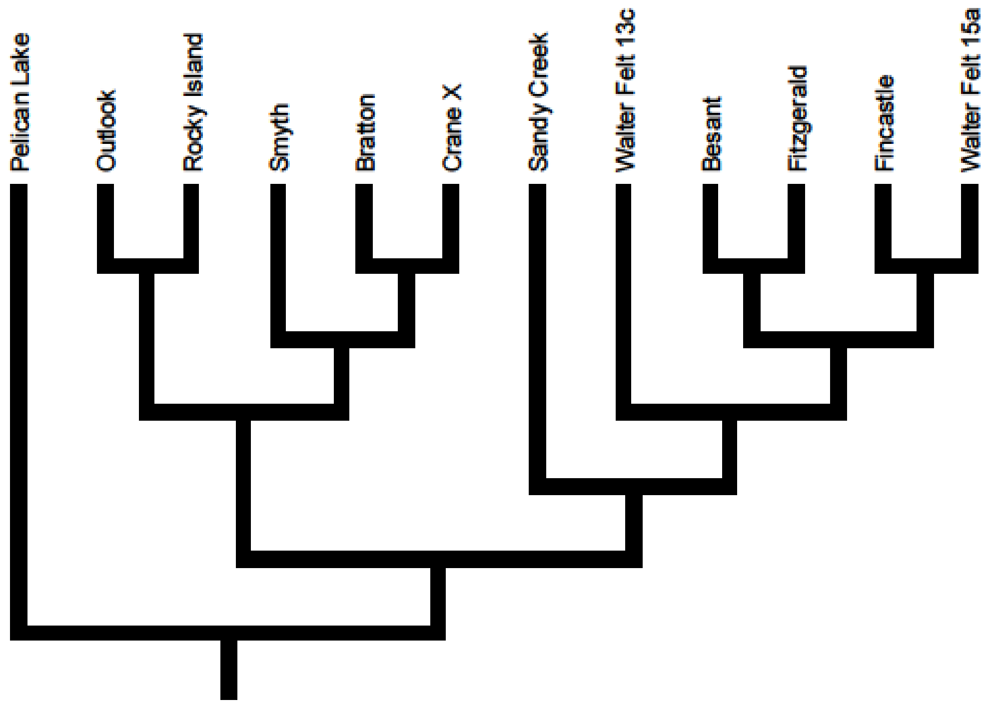

Figure 5.5 Diagrammatic Representation of the data derived from CVA process.

At first this figure (5.5) may seem to show a considerable difference between the Sandy Creek and the Besant assemblages. However, if one was to look at the associated shape change figures in Appendix C (Figures C.26 to C.47) the amount of shape change between the average shapes of these assemblages is almost negligible. This figure is used primarily to show similarities and differences between assemblages and is not a representation of the development or evolution of the point styles, or suggesting that all the styles existed at the same segment of time, as a figure of this style would suggest in biology or geology. What was unexpected as there was no data pertaining to radiocarbon dates or stratigraphic sequences was the almost stratigraphic nature of the diagrammatic representation. In fact only one of the “groups” was well out of order, the Fincastle and Walter Felt 15a assemblages. This is a result of the very similar intergroup nature of the “Besant” and “Intermediate” assemblages. The location of those two (2) aforementioned “out of place” assemblages is very interesting. Level 15 of the Walter Felt site is largely seen as Pelican Lake (Kehoe 1974) or related occupations such as Bracken (Peck 2011) while the Fincastle site has been attributed to Sonota (Varsakis 2006) or Outlook (Peck 2011). What is apparent is the similarity to other Besant assemblages that occur almost 1000 years later in the archaeological record.

The location of the highly variable assemblages (Rocky Island and Bratton) shows a marked similarity to the related assemblages they are paired with and show a combination that will be explored later. The other highly variable assemblages (Sandy Creek and Walter Felt 13c) sit in locations that reflect closer ties to “Besant” than the other “Intermediate” or “Pelican Lake” assemblages as have been suggested previously by Dyck and Morlan (1995) as opposed to Kehoe’s (1974) ideas.

5.4 Arrow vs Dart Metric Testing

The assemblage results of the metric testing can be found here (Tables 5.6, and 5.7) and the individual results can be found in Appendix D. A reverse trend is present to what would be expected. The adaption of the bow and arrow is thought of as one of two transitions: (1) a one way process (Hare et al 2004; Hildebrandt and King 2012) in that once it has been adopted it quickly replaced the atlatl, or (2) that the bow and arrow slowly replaced the atlatl over time as the atlatl still held some advantages (Ames et al 2010; Chatters et al. 1995; Fawcett 1998; Nassaney and Pyle 1999; Webster 1980). The second option appears to be represented by this data. The earliest assemblages contain the most arrow points by ratio. The latest assemblages mainly the Besant and the Fitzgerald assemblages contain the smallest proportions of arrow points or points that straddled the dividing line. Any result that was between -1 and 1 consequently is a result to close to argue definitely in either direction (termed ‘No Decision’). This may be evidence of a point’s transitioning along the technological gap between arrows and darts. In Table 5.7 the raw data is per assemblage is presented. The “mean” shows the predicted mean scores for the assemblages. On the top portion of the table; the more positive the result more likely the assemblage represents the use of atlatls, the more negative the more likely the assemblage represents the use of arrows. On the bottom portion of the table is the means related to the projected neck size of the assemblages, the measurements are in millimetres. An increase in neck width and the associated shaft diameter is seen at the kill site assemblages as compared to the associated camp/habitation site assemblages (Smyth to Pelican Lake, Fincastle and Fitzgerald to Sandy Creek, Walter Felt 13c and 15a and the smaller size of the remaining campsite assemblages Outlook, Rocky Island, Bratton, and Crane). The “standard error’ is the confidence that the mean is actually the mean of assemblage, similarly to the means portrayed in CVA graphs, are dictated by the sample size and the homology of those assemblages. The 95% Confidence Interval is the predicted upper and lower bounds of the distribution of these assemblages.

Table 5.6 Results of Metric Testing per Assemblage.

Site	Besant	Bratton	Crane X	Fin	Fitz	Outlook	Pelican Lake	Rocky Island	Sandy Creek	Smyth	Walter Felt 13c	Walter Felt 15a	Totals
Atlatl	6	0	5	25	26	1	1	0	1	15	2	1	83
Arrow	0	0	2	3	0	1	2	0	2	2	0	1	13
No Decisions	3	2	1	13	8	3	7	2	2	17	4	7	69
No Test	0	0	1	0	3	0	1	0	0	4	0	0	9
Total	9	2	9	41	37	5	11	2	5	38	6	9	174

Table 5.7 Estimated Marginal Means From Results of Arrow vs Dart Metric Testing.

Dependent Variable	Style	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Test Score	Besant	1.534	.504	.539	2.529
	Bratton	-.426	1.068	-2.537	1.685
	Crane (X)	.578	.534	-.477	1.634
	Fincastle	1.477	.236	1.011	1.943
	Fitzgerald	2.190	.259	1.678	2.702
	Outlook	-.813	.676	-2.148	.522
	Pelican Lake	.116	.478	-.828	1.060
	Rocky Island	-.018	1.068	-2.129	2.093
	Sandy Creek	.716	.676	-.619	2.051
	Smyth	.909	.255	.404	1.413
	Walter Felt (13c)	.644	.617	-.575	1.862
	Walter Felt (15a)	.125	.504	-.870	1.120
Neck Width	Besant	15.801	.608	14.600	17.003
	Bratton	12.965	1.290	10.416	15.514
	Crane (X)	12.820	.645	11.546	14.094
	Fincastle	14.749	.285	14.186	15.312
	Fitzgerald	15.779	.313	15.161	16.397
	Outlook	11.772	.816	10.160	13.384
	Pelican Lake	8.663	.577	7.523	9.803
	Rocky Island	12.235	1.290	9.686	14.784
	Sandy Creek	14.964	.816	13.352	16.576
	Smyth	12.039	.308	11.430	12.648
	Walter Felt (13c)	13.337	.745	11.865	14.808
	Walter Felt (15a)	13.028	.608	11.826	14.229

Chapter 6
Interpretations

As mentioned in Chapter One, the purpose of this research is to analyze projectile point selected from a number of Terminal Middle Period Sites with the intention of answering three specific research aims: *Research Aim #1* - Is the point classification used on the Canadian Plains supported by geometric morphometric testing? *Research Aim #2* - Can the projectile points associated with these assemblages be assigned metrically to a known typology, and if not, where do they fit within the Plains point chronology? *Research Aim #3* - Do these projectile points represent a regional adoption of the bow and arrow and is this responsible for the projectile point variation seen during this period?

6.1 Research Aim #1

Is the point classification used on the Canadian Plains supported by geometric morphometric testing?

6.1.1 Cultural History and Projectile Point Classification of the Northern Plains

Since the publication of Wettlaufer's (1955) Mortlach Site monograph, a basic cultural and chronological sequence has been in place on the Canadian Plains. The cultural history on the Northern Plains, particularly during the Terminal Middle Period, is linked to projectile point classification. This basic culture history and point classification has been revised several times (Dyck 1983, Dyck and Morlan 1995, Kehoe 1974, Peck 2011, Reeves 1983, Wettlaufer and Mayer-Oakes 1960). The trend present in all of these is acceptance of a Pelican Lake complex/phase and associated projectile points followed by the Besant complex/phase and its associated projectile points around 2000 B.P. The placement of various lesser known projectile point types or styles (Bracken, Bratton, Outlook, and Sandy Creek) is where the authors differ. Sandy Creek for instance is placed in Besant by some (Dyck and Morlan 1995, Reeves 1983:144) in Pelican Lake (Kehoe 1974) or as a separate entity (Dyck 1983, Peck 2011, Wettlaufer 1955). This is probably the result of limited excavated samples and a rather rare occurrence of basally concave projectile points dating this time period. This is a problem that affected this research as well.

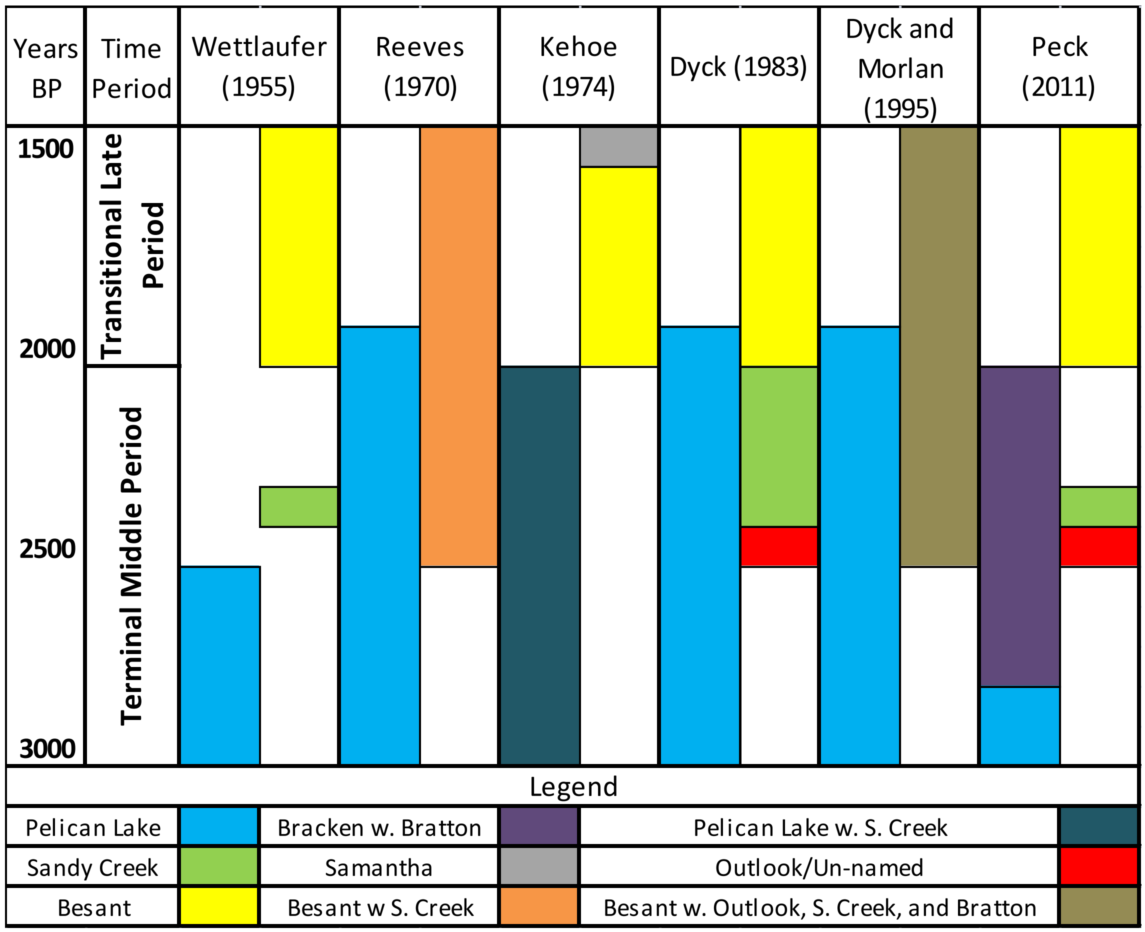

Figure 6.1 Cultural Chronologies and Point Classification of the Northern Plains.

(Reeves 1970 is taken adapted from Reeves 1983)

In regards to the first research aim, and the question whether the cultural chronology and its associated projectile point classification on the Northern Plains holds up to the testing employed in this thesis, the evidence is mixed. In light of the results of this study, no culture chronology presented in this chapter (Figure 6.1) is inherently correct or incorrect. The two most recent volumes (Dyck and Morlan 1995 and Peck 2011) are closer to the results presented in this chapter as one would expect. This is the result of almost a half century of data gathering beyond the seminal work done by Wettlaufer (1955) and countless sites excavated since either Reeves (1970) or Kehoe (1974) addressed the problem. However, even the Dyck and Morlan (1995) and

Peck (2011) chronologies are not without issues. The aforementioned differences in culture history chronology begin to show once one moves beyond the separation of Besant and Pelican Lake. Peck's (2011) work creates divisions where none may exist and combines some projectile point styles where it is not warranted based on morphology alone. Dyck and Morlan's (1995) culture history at first would seem simplified, but the results presented here best fit this chronology. The only major difference is the placement of two point styles into Besant that may be best left as separate entities in an intermediary group.

6.2 Research Aim #2

Can the projectile points associated with these assemblages be assigned metrically to a known typology, and if not, where do they fit within the Plains point chronology?

6.2.1 Bratton/Crane X & Outlook/Rocky Island Assemblages

The previously mentioned cultural sequences place some of these point styles into a variety of phases and complexes. The Bratton point was first identified from Layer XI of the Sjovold site (Dyck and Morlan 1995:379). It is described as a projectile point type that can be either corner or side-notched with a convex base in which the depth of the convexity is greater that 1mm but less than 7mm (Dyck and Morlan 1995:379). Dyck and Morlan (1995:398) suggested that the point style be used to describe convex based points within the Besant Complex. They also note that the point style is common in both Pelican Lake and Besant assemblages and "is not diagnostic of a particular complex or locality", and are found on the Northern Plains from 3000 to 1300 B.P. (Dyck and Morlan 1995:379). Peck (2011:278) suggests that the Bratton style of point fits within the variation encompassed by his omnibus Bracken Phase (to be explained later). Layer XI of the Sjovold site dates from 2500-2200 B.P. (Dyck and Morlan 1995:363).

Outlook projectile points were first identified in layer XIV at the Sjovold site which dates to 2500±85 (S-2060) (CARD 2013 and Dyck and Morlan 1995). They are described as side-notched with broad "u" or "v" shaped notches and generally straight based but may exhibit a slight basal concavity (>1mm) (Dyck and Morlan 1995:437). They suggested the name be used to refer to straight based points in the Besant Complex much like Bratton would be used to refer to convex based points (Dyck and Morlan 1995). Peck (2011:241-242) and Varsakis (2006) suggests the Outlook points represent early Sonota incursions onto the Northern Plains for the purpose of trade. The presence of bone uprights and high frequencies of Knife River Flint lead to the association of the Fincastle site with the Sonota Complex (Varsakis 2006). This, however, would suggest that almost all Besant communal kill sites, and several habitation sites could be defined as Sonota. Syms (1977:90) took a similar view of several other “Besant” kill sites (Walter Felt (levels 10, possibly 13a) and Muhlbach FbPf-1) on similar reasoning. It should be noted that the projectile point assemblages from level 13 (a and c) are dominated by local lithic (see Appendix H) material and do not contain the large elongated Knife River Flint points that Varsakis (2006) or Syms (1977) attribute to Sonota. With this in mind the view of the Besant and Sonota debate taken by this thesis is the one Reeves (1983:13) and Dyck (1983:115) suggest as that the term Besant predates Sonota and due to similarity of the tool kits that Sonota should only be used to refer to the burial mound complex. This will be discussed further with reference to the Fincastle assemblage (below).

The Rocky Island projectile points have been assigned to both the Outlook and the Bratton point types (Frary 2009:137-139). The Rocky Island site dates to 2475±120 (S-2437) (CARD 2013). The Crane site’s Level X projectile points are described in two categories as adherent Besant points and Pelican Lake projectile points (Gibson and McKeand 2010). Level X of the Crane site dates to 1970±70 (S-3212) (CARD 2013).

The analysis from this point on will use the terms Mahalanobis and Procrustes distances. As a refresher they are a measure of similarity in shape space between assemblage/group means. For reference, the two furthest (most dissimilar) assemblages examined including Pelican Lake and Besant/Sandy Lake and these have a Mahalanobis (M-distance) and Procrustes distances (P-distance) of 6.1429 and 0.3478 respectively. The permutation tests serve to test whether the observed difference between the assemblage/group means is large enough to reject the null hypothesis that the two groups have identical shape. The respective p-values for the above reference is <0.0001 (Mahalanobis (M) p-value) and <0.0001 (Procrustes (P) p-value) respectively suggests a very low chance of similarity.

The Bratton and Crane X assemblages showed a marked similarity not just in visual similarity but in morphology. They had a Mahalanobis distance of 2.571, p-value 0.1877 based on that distance, a Procrustes distance of 0.1126, and a p-value of 0.4275 based on that distance.

The DFA follows the same trend showing a correct classification rate of 52.8% based on cross validation testing. This would suggest to a level of certainty that these two assemblages are similar enough to consider them from highly related assemblages. As the cultural identity of Crane occupation X is not named specifically, I would suggest the Crane X assemblage, specifically the side-notched convex based projectile points (adherent Besant) be referred to as Bratton projectile points.

Contrary to Peck (2011:278) The Outlook projectile points from Sjovold XIV do not compare favourably to the Fincastle projectile points: M-distance: 2.7055, M p-value: 0.0014, P-distance: 0.131, P p-value: 0.0015, and cross validation based correct classification rate: 98.8%. In fact, only one point was misclassified between these two groups and it was a point from the Fincastle site. Similarly, Dyck and Morlan's (1995:437) argument for a Besant association is unsupported, M-distance: 2.5401, M p-value: 0.0014, P-distance: 0.1309, P p-value: 0.0074, and cross validation based correct classification rate: 84.4%. Thus the question of where the Outlook points should fit within the cultural chronology remains open. The answer, however, may be found with the Rocky Island site data.

The points from the Rocky Island site have been assigned to both the Bratton and Outlook style. The sample size is small (n=2) but p-values for Outlook vs Rocky Island (M-distances: 0.3973 and P-distances: 0.4903), Bratton vs Rocky Island (M-distance: <0.0001 and P-distances: 0.3438), and Crane X vs Rocky Island M-distance (0.1661) and P-distances (0.094) mostly compare favourably. The DFA cross validation also suggests a similarity, with scores of 20%, 25%, and 27.8% respectively for the correct classification rates. The DFA computed within the MorphoJ program had a very difficult time correctly classifying the Rocky Island and Bratton points in general due to the fact the sample size was less than desirable. However, these three values were the lowest seen, suggesting that there may be something more to the data then just the numbers suggest.

The four assemblages (Bratton, Crane X, Outlook, and Rocky Island) show some level of interconnectedness. This, combined with vague similarities in shape (Tables 5.3) and DFA rates (Table 5.4) between them and Pelican Lake, and, with the early Besant assemblages suggests an intermediary assemblage. It would appear from the radiocarbon dates that Besant in its earliest inceptions did not evolve technologically out of Pelican Lake. However, the Pelican Lake

Complex seems to have overlapped with the Besant Complex, and based on this data, was heavily influenced by Besant at least on the Saskatchewan Plains. The diagrammatic representation derived from the CVA data supports such an interpretation, as this group (Bratton, Crane X, Outlook, and Rocky Island) of associated assemblages sit between Pelican Lake and Besant. As previously mentioned, Dyck and Morlan (1995) state that the Bratton point style is found in Pelican Lake and Besant assemblages dating from 3000-1300 B.P.. Layer X at the Sjovold site contains a mix of both Besant and Pelican Lake points (Dyck and Morlan 1995:350-351). Peck (2011) attributes these to the Bracken Complex in which he placed the Bratton points yet it seems more likely that this represents an intermediate assemblage. Level 4C at the Mortlach site may be another level in which an intermediate assemblage may be present. Level 13c at the Walter Felt site contains a small number of convex based side-notched and some corner-notched projectile points (Figure 4.2). As the average shape of the assemblage and its classification rates place it closer to Besant, the appearance of these intermediate forms lends credence to the idea of late Pelican Lake transitioning into Besant.

Peck (2011:245-247) names two sites (Happy Valley [EgPn-290] and Head-Smashed-In [DkPj-1]) in addition to the Fincastle site that he sees as evidence of the Outlook Complex. Yet the descriptions of the projectile points provided by Peck (2011) this placement with Fincastle and possibly early Besant may be incorrect. The presence of Pelican Lake and adherent Besant projectile points in these is assemblages suggests that these assemblages may be better placed with this group of Intermediate assemblages along with the original Outlook assemblage.

Outlook style points (Sjovold XIV) may very well be a small early form of Besant point or may have been used by earlier Eastern Woodland groups expanding either their influence or territory onto the Plains as Dyck and Morlan (1995) suggested. However, with the small sample size and results from this analysis, I suggest they be tentatively placed within an Intermediate Series containing assemblages analyzed in this study. It is constructed from the Bratton (Level XI of the Sjovold site), Outlook (level XIV of the Sjovold site), Crane X assemblage (occupation X of the Crane site), and the Rocky Island site assemblages. The Intermediate series includes two main point types the convex based Bratton point exhibiting both side and corner-notching and the straight to slightly concave based, side-notched Outlook points. The Bratton points seem to appear throughout the date range while the Outlook points seem to only be present in the earlier

2500-2400 B.P. assemblages hence the usage of the term series. Ultimately a more complete understanding of the Outlook and Bratton point styles and their relationship to Besant and Pelican Lake a larger collection of projectile points would be required (which in turn entails excavation of more sites dating to this time period).

6.2.2 Besant/ Fitzgerald/ Fincastle/ Walter Felt 15a / Walter Felt 13c/ Sandy Creek Assemblages

As expected, the CVA and DFA showed a distinct separation of the Pelican Lake composite group from the Besant composite group. This placement also positioned the Besant composite group almost dead centre for an interesting nexus of related assemblages (Figure 5.1 to 5.3). Some assemblages were expected to be similar, but the assemblages that were associated with this cluster were interesting. The assemblages in this cluster (Fitzgerald/ Fincastle/ Walter Felt 15a / Walter Felt 13c/ Sandy Creek Assemblages) showed a Mahalanobis distance of 1.61 or less when compared to the Besant Composite (Pelican Lake's is 5.6574). The Fitzgerald site (a known Besant kill site) tested similar to the Besant composite (M-distance: 1.0271, P-distance: 0.0716) but vaguely in regards to p-values (M p-value: 0.2497, P p-value: 0.0469). This is believed to be a result of either sample size or site type differences although the DFA resulted in a 62.9% correct classification rate suggesting increased similarity. This would seem to confirm Hjermstad's (1996) previous placement of the Fitzgerald site within the Besant Complex.

As well, the Fitzgerald assemblage tested very similar to the other Besant like kill site (Fincastle) as well with a correct classification rate of 72.9% between the two sites (Fitzgerald and Fincastle). The Fincastle and Besant composite assemblages were difficult for the DFA to separate (64.4% correct classification rate), but showed a larger amount of variation than was evident between the Fitzgerald and Besant assemblages (Besant vs Fincastle, M-distance: 1.3644, M p-value: 0.0113, P-distance: 0.0779, P p-value: 0.0219). Again this difference between the Besant composite and the Fincastle assemblage may be a result of a difference in sample size or site type. However, this variation in shape as defined by the CVA process is not surprising. There is over 1000 years time difference between the Besant composite assemblage and the Fincastle assemblage. The answer to linking the assemblages comes from level 15a of the Walter Felt site.

The lower levels of the Walter Felt site (15a – 15d), much like the Mortlach site, represent a camp/habitation site. Just as the assemblage from the Mortlach site showed similarities to a Besant kill site from a similar time span (Fitzgerald), level 15a from the Walter Felt site shows similarities to a kill site from a similar temporal episode. Level 15a from the Walter Felt site has been assigned both to the Pelican Lake Complex (Kehoe 1974:111) and to the Bracken Phase (Peck 2011:227). The testing employed here suggests it is closer in form to Besant than to either Pelican Lake or Bracken. The DFA correct classification rates show a stronger identification and classification in respect to Pelican Lake (95.5%) and Bracken (94.5%) assemblages, with a weaker separation from the Besant (61.5%), Fitzgerald (60.7%), or Fincastle assemblages (54.7%). The CVA data again mimics DFA findings further suggesting that level 15a of the Walter Felt site is closer in morphology to the Besant style of projectile points than the Pelican Lake points as suggested by Kehoe (1974) or Peck (2011). As mentioned, the Fincastle assemblage was very similar to level 15a which was very similar to Besant. This similarity between the Walter Felt level 15a and the Fincastle assemblages and, in turn, the similarity to the Besant and Fitzgerald assemblages suggests a rough morphological continuity from around 2500 B.P. to very near the end of the Besant Complex (1300 B.P.). The Walter Felt 15a assemblage showed similarities to some of the other "Intermediate" assemblages previously named and to the Walter Felt 13c assemblage. The occasional highly variable projectile point within the assemblage may be responsible for that. This same trend in similarity to the "Intermediate" assemblages is portrayed by the younger Walter Felt 13c level and may be evidence of either stratigraphic mixing or the presence of these intermediate point styles in some of the lower levels of the site. With the morphological similarities shown between these assemblages and difficulty of the DFA to separate them, it would appear safe to suggest that both the Fincastle and Walter Felt 15a contain Besant Complex points.

An attempt was made to distinguish a possible Sonota assemblage from a Besant assemblage. With the placement of the Fincastle assemblage in the Besant Complex a difference was not observed. To reiterate the view of the Besant and Sonota debate taken by this thesis, Sonota is used to refer to the Besant burial mound complex. In reference to the projectile points, the notable difference between the nearly identical "Sonota" and "Besant" points seems to be related to length (Syms 1977:92). This is inherently related to material type usage within these sites such that higher quality material result in longer points (Varsakis 2006:301-302). As the most common attribute to be reduced when resharpening is length, it has little bearing on determining point styles (Holmer 1978; Walker 1992) and as such the “elongated Sonota” points likely represent points lost or abandoned earlier in their life cycle in comparison to the shorter “squatter Besant” points as defined by Syms (1977:92). The smaller points may also be a reaction to and adoption of local lithic material (Finnigan and Johnson 1984:32). As no “Sonota” points from burial mounds in the Middle Missouri were examined, the variance in point styles is not examined in depth. However, if the difference is as subjective as described above, variation would likely be limited if such points were subjected to the same analysis. Sonota as such would appear to be best lumped into the Besant Complex and limited to the burial tradition.

As mentioned, the other assemblage at the Walter Felt site that was analyzed was from level 13c; which along with 13a have been identified as a Besant assemblage by both Kehoe (1974:108) and Peck (2011:237). This level appears most similar to the Walter Felt 15a assemblage (M-distance: 1.2723, M p-value: 0.6159, P-distance: 0.0669, P p-value: 0.6095), while the DFA classification rate was 55.6%. If the Walter Felt 15a assemblage is indeed a Besant assemblage, then it would also be safe to assume that the Walter Felt 13c assemblage is also a Besant assemblage. However, as noted this assemblage showed similarities to every one of the assemblages to a varying degree with the exception of the Pelican Lake and Smyth assemblages. This is may show that the very diverse projectile point morphology as a result of transitioning styles. This suggests that the assemblage may be better placed in the Intermediate Series. However, due to a proportionally higher similarity to the aforementioned Besant assemblages than to the Intermediate assemblages and the uncertain nature of the stratigraphy, this assemblage will remain as a Besant assemblage (as suggested by other researchers) for the purpose of this study.

The Sandy Creek Complex first described by Wettlaufer (1955), has had a colourful history. The Sandy Creek composite assemblage is situated right along the transitioning line between Outlook/Bratton and the earlier Besant assemblages (Figure 5.4). This is evident by the individual DFA results which most weakly separated the Sandy Creek points from those from the Outlook (50%), Rocky Island (60%), Fincastle (75.1%) and Besant (74.4%) assemblages (See Table 5.4). The morphological similarities from the CVA align it closer with the Besant (M-distance: 1.5395, M p-value: 0.3097, P-distance: 0.0907, P p-value: 0.1719) or Walter Felt 15a

(M-distance: 1.886, M p-value: 0.1074, P-distance: 0.1591, P p-value: 0.2193) assemblages. The CVA and DFA testing that was conducted shows that Sandy Creek may not exist as its own entity, but instead is associated with Besant particularly earlier Besant assemblages. This idea is supported by Reeves (1983:144) who did not see a difference between Sandy Creek and Besant points, and to a certain extent by Dyck and Morlan (1995:398), who grouped Sandy Creek into Besant as its own point style. Within the analyzed assemblages the range of variation seen within the Besant composite group, Walter Felt 15a and 13c as well as the Besant kill sites (Fitzgerald and Fincastle) where no "Sandy Creek" points were identified suggests that at this time the Sandy Creek point style with the limited samples available should be placed within Besant. The size and morphology of the Sandy Creek points may be tied to the use of local material; a similar trend is seen in the Walter Felt 13c and 15a assemblages.

From the assemblages reviewed in this research it would appear that the Besant Complex has a deeper time depth than thought by Peck (2011). On the other hand Dyck and Morlan (1995) and Reeves (1983) grouped Sandy Creek with Besant pushing back the time depth to a date supported by this analysis. Peck (2011:247) suggests that these earlier assemblages (i.e. Fincastle) may represent Besant but that until more assemblages are found bridging the gap would not identify them as Besant. The assemblages analyzed here would seem to fill that gap, Mortlach 4D: >1580±325 (S-22), Mortlach 4E: 2400±290 (S-28), Walter Felt 13c >1610±70 (S-200), Walter Felt 15a: <2430±90 (S-279), and Sjovold XII: 2355±105 (S-2059) (CARD 2013, Dyck and Morlan 1995, Kehoe 1974, Wettlaufer 1955). The assemblages reviewed here (Fitzgerald, Fincastle, Walter Felt 15a, Walter Felt 13c, the Sandy Creek and Besant composites) show enough similarity to be tentatively placed within the umbrella of Besant. Until more data can be obtained that would suggest otherwise these assemblages should all be considered part of the Besant Complex.

6.2.3 Pelican Lake/Smyth Assemblages

The two most distinct assemblages analyzed in this thesis were the Pelican Lake composite assemblage and the assemblage from the Smyth site. These assemblages were classified correctly at 90.9% and 89.5% respectively. The Pelican Lake assemblage was very weakly separated from was the Smyth Site assemblage (63.6% in Table 5.4). The Smyth site assemblage was originally identified as Pelican Lake during excavation and in later reporting (Landals 2009). However, Peck (2011) subsequently attributed it to his Bracken Phase.

As Peck (2011:256-257) describes it, the Bracken Phase, represents the start of communal bison hunting on the plains and includes almost all late Pelican Lake sites, 2800-2000 B.P., that contain corner-notched points with obtuse shoulders and wide necks. Dyck (1983:105) also mentions a transition in Pelican Lake point morphology from narrow necks to wide necks. Peck (2011:236-237) considers the earlier Pelican Lake assemblages (3600-2800 B.P.) at sites such as Walter Felt, Long Creek, and Mortlach to be culturally unrelated to the later Bracken Phase, on the premise of the adoption of large scale communal hunting. However, the "classic" Pelican Lake assemblage from Long Creek dates to 2230±100 (S-49 a) (Bryant 2002, CARD 2013), which would place it at the tail end of the Bracken Phase and not in the Pelican Lake Complex as defined by Peck. Peck (2011:241) notes the Pelican Lake Complex and Bracken Phase toolkits share several traits. It may well be that the change is simply technological or functional change and not cultural at all. With the morphological similarities seen between the Pelican Lake and Smyth assemblages in terms of the DFA (63.6% correct classification rate), but not mirrored in the CVA (M-distance: 2.9532, M p-value: <0.0001, P-distance: 0.1591, P p-value: <0.0001), the correct placement of Pelican Lake/Smyth is difficult. The answer would seem to lie in the advent of larger scale communal hunting as Peck (2011) suggests, but with an emphasis on how this affects point shape.

As is discussed in the next section, a more substantial and sturdier point may be required in communal hunting situation. The design of a Pelican Lake point only allows an increase in mass and sturdiness in so many ways. It can be made thicker or the neck can be made more substantial and as such eliminating the barbs. The latter would produce a different looking projectile point compared to the classic narrow necked Pelican Lake points and would appear similar to the Smyth assemblage points. The similar size change appears to occur with the Besant kill site assemblages (Fitzgerald and Fincastle) as well. The neck width increases at these sites and they are overall larger and more robust as is presented in Table 5.7 and in Appendix D; D.4 and D.5. The "Besant" kill site projectile points do not differ morphologically. Contrarily, it should be noted that the lack of distinct barbs and a thicker neck seen in the Smyth assemblage creates a different morphological shape. The loss of the barbs is seen in the later Pelican

Lake/Bracken assemblages is believed to reflect a shift in hunting strategies (Kehoe 1974:104, Peck 2011:241). In solitary hunting the barbs would ensure shaft retention and as a result increase the damage dealt by the projectile. With the need for shaft retention no longer providing a functional advantage in a communal kill,, one would expect the morphology of the point could change in these situations. As mentioned along with the reduction of the barb an increase in size would be expected. The Smyth site assemblage tests very similar to the Pelican Lake assemblage and most likely represents a Pelican Lake communal kill site assemblage.

However, as pointed out by Dyck (1983), Dyck and Morlan (1995), Kehoe (1974), Reeves (1983), and Peck (2011) the Pelican Lake style of projectile point changes through time and should probably be divided into different styles. This change, however, should be approached with caution as overzealous combinations designed to separate the large variation of styles seen in the Pelican Lake projectile points into portions may result in even larger omnibus groupings. An example of this is Peck's (2011) Bracken Phase as it includes an assemblage that tests morphologically as Besant (Walter Felt 15a). The differences in point styles between the Pelican Lake Complex and Bracken Phase may not represent significant differences cultural and as such should not be separated into different cultural units or entities. Instead they should be considered the Pelican Lake Series, similar to the McKean Series.

The need for careful separation is paramount as the division of projectile points in relation to Pelican Lake assemblages is related to a functional difference, and not a cultural one. As such, the name suggested for the point style from the Smyth site is Bracken as named by Peck (2011) (based on Kehoe's 1974 work). The use of the name does not reflect a following of the division of Pelican Lake as proposed by Peck (2011) but instead follows the standard naming convention present in archaeology. It encompasses the broadly corner-notched projectile points with wider necks and convex to straight bases found in Pelican Lake sites, and represent a technological and functional shift to communal bison procurement. The other point style found commonly in Pelican Lake assemblages, are the barbed, narrow necked corner-notched points also analyzed here and are referred to as Classic Pelican Lake (after Kehoe 1974:108-109). Although Bracken points are more directly associated with communal hunting they may still be found in direct association with Classic Pelican Lake points as is the case at DjPm-114 (Peck 2011:258 plate 21 "u" and "v") a buried campsite in southwestern Alberta. However, to fully test this naming classification and to better understand the impact of communal hunting on point morphology, a further study of Pelican Lake kill and habitation/camp sites is required.

6.3 Research Aim #3

Do these projectile points represent a regional adaptation to the bow and arrow and is this responsible for the projectile point variation seen during this period?

In order to come to a conclusion concerning the interpretation of the results of the metric testing related to arrow and darts, and whether a technological innovation is responsible for the morphological variation seen, a review of the advantages of both the arrow and atlatl dart presented in Chapter Three must be considered. The advantages of the bow and arrow are: (1) its greater accuracy; (2) its longer effective range; (3) the smaller range of motion for use; (4) the higher rate of fire and can carry more projectiles in the same amount of space; (5) the reduced material requirement (due to size easier to make); and (6) shorter learning curve (Christenson 1986:122). Although not as numerous, Christenson (1986:122) also supplies reason why the atlatl would be superior to the bow and arrow: (1) the atlatl requires only one hand to use; (2) the atlatl is easier to manufacture and maintain; (3) the dart has a higher impact force than the arrow. With this in mind, the data presented in this chapter can be interpreted in one of two ways; (1), the atlatl and bow served side by side for over 1000 years before completely being replaced in this portion of the Northern Plains. (2), that the groups from this time period produced a wide size range of projectile points for various tasks without necessarily producing projectile points that were delivered from a bow and arrow. These two avenues of thought are not as mutually exclusive as they would seem at first.

The first argument would suggest a period of apparent technological stalemate as both the bow and arrow and the atlatl competed for use. The data presented here would also suggest a possible regression as the atlatl was the preferred weapon system in the assemblages used in the later portion of the Terminal Middle Period particularly those from kill sites. This regression is possible, but one must consider these advantages and disadvantages of the bow and arrow over the atlatl mentioned previously. With so many advantages one would have to ask why not switch weapon systems? Is the apparent reoccurrence of atlatl use an example of conservatism, or is that weapon system better designed for the organized chaos of the bison pound?

The answer to this query may be found in the second avenue of thought involving a divergence in the tool kit which may pertain to a wider spectrum of intended targets or manufactures in some types of sites compared to others. The one obvious trend in the data suggests that at kill sites, points of different sizes were produced in the same general shape. Out of the sites with the four (4) highest means from the metric testing three (3) are kill sites (Fitzgerald, Fincastle, and Smyth). This leaves only the Besant type site at Mortlach as the lone camp/habitation site in the top four.

The question of why a sturdier projectile point such as a dart would be required at a kill site is multi-causal. From a technological perspective Raymond (1986) and Shott (1993) both note that the atlatls would be beneficial in hunting large game. Ceremony and ritual also would have played a large role in communal hunting (Brink 2008, Frison 2004, Kehoe 1967, Kehoe 1973, Schaeffer 1978) and therefore could impact the assemblages associated with sites of this nature.

As mentioned, the atlatl could be preferred for large game due to its higher impact force (Raymond 1986, Shott 1993). As bison are large game, the points and weapons system used to dispatch them would be expected to be larger than those used to dispatch smaller game such as deer and pronghorn. The bow and arrow maybe the technology of choice for hunting smaller game (Shott 1993) and would reflect a wider range of game species and a more opportunistic style of hunting that the remains of a camp/habitation site may be representing. Similar evidence is also seen in the arctic where harpoon size in both shaft and projectile increased in relation to prey size (Arnold 1989:81). The metric testing score differences between the two types of sites (camp/habitation and kill sites) would suggest that a similar trend is present here (Table D.5). The kill sites used in this study all represent a pound or other entrapment site in which the bison are driven into a corral and dispatched in the corral. In the confines of a corral, range is not a limiting factor. This addresses the atlatls main drawback (Bergman et al 1988:666), as they are contained a short distance from the hunter. In the mass chaos of twisting panicked bison, the breakage of weapons shafts would be high. A sturdier shaft presented by an atlatl could have been highly desirable as the potential of repair would be decreased even if just minimally. The added weight of the shaft and larger point would also allow the ribs to pose less of an obstruction to the projectile. The atlatl in Mesoamerica was more feared than the bow by the Spanish for the ease with which atlatl darts penetrate their armour (Raymond 1986:173). The bison is not armoured, but a weapon capable of delivering enough force to penetrate armour would clearly not suffer the fate of impacting a rib or similar flat bone to the same degree as a lighter arrow. The spear like design of a the atlatl would also allow for repeated thrusting of the shaft in a spear or lance like fashion as the animals neared the walls of the corral if required while the one handed operation would allow the other used to bolster the corral if needed. Also of consideration would be the economic cost of where the animals would eventually die of their wounds. The desire to inflict a large amount of damage dispatching the animals in the confinements of the corral before they spilled out and escaped to die of their wounds in some isolated coulee or river bottom would be paramount. Although an arrow can inflict a lethal wound through the vital organs and/or severing blood vessel resulting in eventual blood loss, impact trauma (or force transferred to the target) and blood loss will force an animal to succumb to their injuries faster. A heavy dart launched from an atlatl will have higher momentum and kinetic energy (Bergman et al 1988:666; Chatters et al 1995:761; Raymond 1986:172), upwards of four times the joules (energy) exerted by modern bows (Bruchert and Hutchings 1997:894; Hutchings 2011). This increase in power will transfer the higher force of impact into the target than a lighter and smaller arrow will. This will damage more soft tissue and also result in a larger wound.

Communal hunting on the Plains, particularly of bison, was an endeavour steeped in ritual and ceremony (Brink 2008; Frison 2004; Kehoe 1967, 1973; Schaeffer 1978). Certain limitations and protocols not preserved in the archaeological record would have been observed by those involved. This opens another avenue of exploration to the projectile points that are left behind. Several authors suggest that the choice of weapon and the projectile points produced may be linked to these very factors.

Nassaney and Pyle (1999:259) suggest that “traditional weapons (e.g., darts) might have been retained in cooperative activities such as game drives, whereas lone hunters would have found the bow and arrow to be more effective”. If one considers the size differences the metric testing displays a pattern starts to emerge of larger points being present at the kill sites as opposed to the camp/habitation sites. Bamforth (1991:312) in looking at Paleoindian assemblages suggests that kill site assemblages "represents a restricted portion of the total variance" within a group of projectile points adhering to a possible stricter set of norms. He also suggests that the assemblages would have been produced by the most skilled craftsmen applying their own variation on the norms (Bamforth 1991).

Therefore, the case can be made for the dart or at least larger sturdier projectiles being more advantageous for cooperative style large game hunts, while the bow and arrow would benefit lone or solitary hunters more. The possibility that cultural norms associated with communal hunting may have dictated the use of larger projectile points. What is left unanswered is the apparent early appearance of the bow and arrow in the Pelican Lake and Outlook camp/habitation sites.

Two theories of bow and arrow diffusion exist in the literature but seem to be largely at odds with each other. To several authors (Ames et al 2010, Chatters et al. 1995; Fawcett 1998; Webster 1980) the two weapon technologies seemed to serve side by side for a prolonged period of time. Others (Blitz 1988, Hare et al 2004, and Hildebrandt and King 2012) see the transition to be one way, with the bow and arrow rapidly replacing the atlatl. In some portions of the Americas mainly Mexico, the atlatl was used right up until contact with the Spanish (Nassaney and Pyle 1999) with very effective results. This would suggest that the atlatl maintained some advantages over the bow and arrow. These views offer two very divergent patterns of diffusion of bow and arrow technology in North America. They are summarized again by Nassaney and Pyle (1999) in that the individual needs and requirements of particular groups would dictate how fast the transition to the newer technology would be undertaken, if at all.

So are these Terminal Middle Period camp/habitation sites early examples of bow and arrow technology on the Northern Plains? Reeves (1983) proposed that the bow and arrow was brought on to the Plains during the Pelican Lake Phase through contact with Plateau groups from British Columbia. Other authors (Wettlaufer 1955, Dyck 1983, Dyck and Morlan 1995) also suggest the association of the bow and arrow with Pelican Lake assemblages. The data analyzed here would suggest a similar trend with some Pelican Lake points being classified as arrowheads (summarized in Table 5.6, 5.7, and Appendix D). Reeves' (1983) suggestion that Pelican Lake's close ties to British Columbia and associated intermountain groups may be the source of bow and arrow technology in Pelican Lake assemblages.

Morrissey (2009) in a study attempting to determine when the bow and arrow was adopted in the Plateau region of British Columbia, places the earliest use during the Shuswaps Horizon (3500-2400 B.P.) and complete replacement of the atlatl by the end of the Plateau Horizon (2400-1200 B.P.). In his study, Morrissey (2009) utilizes the same equation developed by Shott (1997) as used in this research. The earlier Plateau Horizon points are visually very similar to Pelican Lake points while the Shuswaps Horizon points appear similar to earlier Middle Period projectile points. Considering the Pelican Lake composite assemblage and associated arrow points pre-date the similar Plateau Horizon points, if the bow and arrow was introduced from the British Columbia Plateau it would have been from the earlier Shuswaps Horizon. A Pelican Lake projectile point (not included in this analysis) from level XX of the Sjovold site dating to 3595±150 B.P (S-2061) (CARD) has been classified as an arrow point (Dyck and Morlan 1995) using Thomas' (1978) equation and subsequently by the author using Shott's (1997) equation. Unless bow and arrow technology was spread rapidly between peoples of the Shuswaps Horizon and the Pelican Lake Phase a new distribution path will have to be explored.

As several studies have stated (Ames et al 2010; Bradbury 1997; Nassaney and Pyle 1999; Odell 1988; and Shott 1997), bow and arrow technology may have been available earlier than 3500 B.P. in many region of North America. Odell (1988) suggests that impact fractures common on some unifacial points may represent some of the earliest arrow points in the Mid-West. In this study flake points were removed from the database on account of the attribute variability displayed by them (Dawe 1997; Hjermstad 1996). As a result, the possibility that flake points served as arrow points is one beyond this study. Nevertheless, it should be noted that at the Fitzgerald site (ElNp-8) several small unifacial and marginally retouched points were recovered as well as some larger flake points that are morphologically similar to the bifacial points; however, these were in nowhere near the numbers of the latter. In this regard, a particularly telling idea is put forth by Railey (2010), who argues that the adoption of the bow and arrow is marked by the subsequent adoption of expedient tool manufacture.

The other question that remains is whether the projectile points identified as arrow points are actually arrow points or are they just smaller darts for smaller targets or simply toys? More recent evidence from the Yukon (Hare et al 2004) and the Great Basin (Hildebrandt and King 2012), would suggest a quick and swift transition from atlatl and dart to bow and arrow. With the exception of one anomalous date (Hare et al 2004:267), the time frame suggested for the adoption of the bow and arrow follows closely to the timeline proposed by Blitz (1988:132) in that the bow and arrow was adopted around 1200 to 1500 B.P. in most of North and Western North America.

However, in the Yukon the intended game and style of hunting may have restricted the use/adoption of the bow and arrow in these particular high alpine sites. The caribou that frequent the high alpine ice patches are a highly gregarious member of the deer family. Behind only the bison, elk and moose, they are the largest ungulate in North America (Patten and Anderson 1981). Caribou are clearly larger than the deer, mountain sheep, and goats that would inhabit the area at different elevations around the ice patches. The open nature and lack of vegetation would be an ideal space for the atlatl (Morrissey 2009; Nassaney and Pyle 1999). The congregated mass of caribou on the ice patch would may serve a similar purpose to the bison pound, in that the caribou were at least temporarily confined and congregated, in which a volley of darts would have dire consequences. A complete arrow shaft with a nock had returned two dates, 3510±70 (Beta-136341) and 3600±40 (Beta-140630). This would suggest a possible very early date for bow and arrow technology. The absence of the bow and arrow for another 2000 years on the ice patches could be a result of the atlatl outperforming the bow and arrow technology used at that time (Bergman et al 1988:666; Bruchert and Hutchings 1997; and Chatters et al 1995:761). The early date on the arrow shaft could be an early experimentation of bow technology. If the dates at ca. 3500 B.P. from the Yukon ice patches are indeed correct it would match very closely with the dates on assemblages that metrically test positive for the presence of arrow points on the Plains and the Interior Plateau and help to demonstrate an early diffusion of bow and arrow technology. However, if small toys were present in sites (Dawe 1997) this may skew this early data from the Plains and the Plateau.

Dawe (1997) makes the case that the small misshapen and unifacial retouched points found in some campsites to have been children’s toys. This possibility was avoided in this study through the rejection of unifacial and marginally modified flake points for morphometric and metric analysis. The ethnographic evidence portrayed by Dawe (1997) brought up many a memory from my childhood. Hunting to my family was very important, though nowhere as important as it would be or has been to First Nations peoples. There are several photographs of me at the age of three or four shooting my toy bows at animals my father had dispatched with his bow. As my siblings and I got older we were given more powerful bows and pellet guns and the three of us kept the ground squirrel and small bird population under control and the cats well fed. When I had grown I was brought along on easier big hunts to learn how to stalk and understand the game that was hunted. On those hunts I had my own set of smaller hunting gear minus a weapon. I did, however, get a youth model bow and a smaller gauge shotgun so I could continue my learning of how to shoot. I tagged along until I was old enough to hunt on my own. A childhood separated by hundreds of years and urbanization still reflected the ethnographic data to which my father had no experience. To him it was just the best way to get us interested and perfect our skills. To date most major manufacturers of hunting accessories, bows, and firearms produce youth models. In a society where hunting has become a pastime or a novelty the idea of scaled down weaponry still exists, so it must have been very important a society where hunting either lead to the success or death of a group. It is obvious that toy weapons would have to be represented in some archaeological sites somewhere, and the "early" unifacial "arrow" points may be representative of this. This, then, does question the theories of bow and arrow dispersal which use flake points as evidence.

As for whether the adoption of the bow and arrow is responsible for morphological variation, the data does indicate that projectile points in the camp/habitation sites are markedly smaller. Lyman et. al (2008) and Lyman et. al (2009) suggest that as a new technology (such as the bow and arrow) is being adopted, a florescence of variance should be present. In their studies of projectile variation associated with the adoption of the bow and arrow, this variation is believed to be the result of the experimentation process of developing the most effective projectile within a set of norms. After such a period of experimentation the variation should taper off (Lyman et al 2008, Lyman et al 2009) leaving the most successful designs. On the majority of the Northern Plains the variable collection of Besant style points (Dyck and Morlan 1995; Kehoe 1974) are replaced by the very uniform Avonlea style of projectile points (Dyck 1983) which are seen as the quintessential Plains arrowheads. This follows nicely with Lyman et al

(2008) proposed decline in point variation. The eventual replacement of the atlatl with the wide spread adoption of the bow and arrow on the Northern Plains are likely the result of improvements in bow and arrow technology surpassing the atlatl in performance and a change in procurement strategies. Lyman et al (2008) and Lyman et al (2009) also suggest that many early arrows may be routinely misclassified as darts, and the classification scores from this study are evidence of that. There was a large amount of “No Decision” results with the points being too close to the dividing line to distinguish them which are very similar to the data from this analysis. It would seem that starting around 2500 B.P. the bow and arrow was present on the Northern Plains and may be responsible for the variation in the projectile points found in the Terminal Middle Period.

6.4 A Proposed Revision of Cultural Chronology

The latest cultural chronology by Peck (2011) was critiqued in the previous chapter. This was especially apparent in reference to the connections he infers between material from Alberta and Saskatchewan. This is most likely a result of not having access to some of the sites and materials that was available for this study. With this in mind, the findings of this study are presented here in a proposed Cultural Chronology has been assembled (Figure 6.3). It consists of three major Terminal Middle/Transitional Late Period cultural units based on the assemblages studied in this analysis. These cultural units are; the Pelican Lake Series, the Intermediate Series and the Besant Complex. The point styles of these groups cluster nicely and separate out effectively with the exception of the previously noted point styles of the proposed Pelican Lake Series (Figure 6.2, and Appendix E).

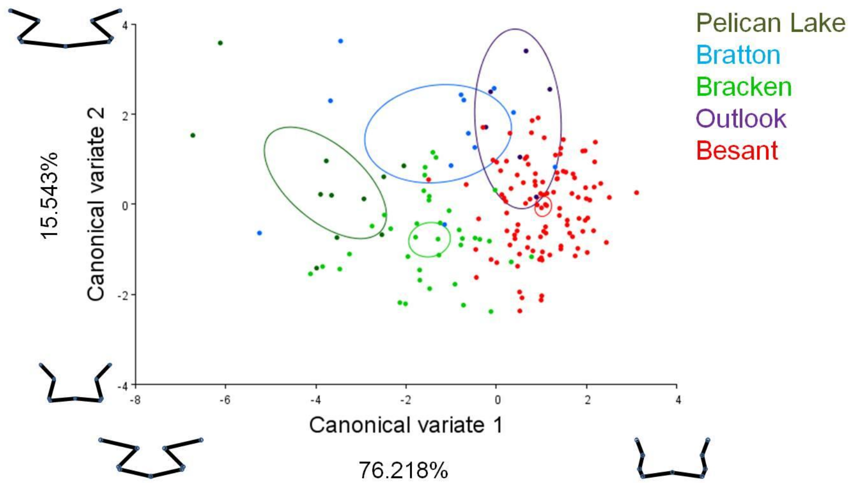

Figure 6.2 CVA 1 against CVA 2 with means displayed.

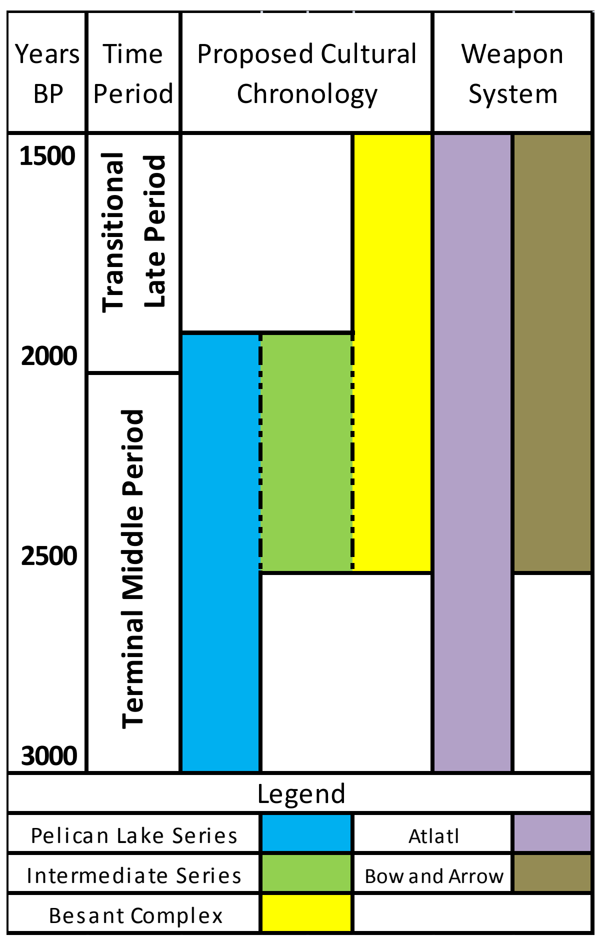

Figure 6.3 Proposed Cultural Chronology.

The Pelican Lake Series (3600-2000 B.P.) throughout its time span contains Classic Pelican Lake points described as corner-notched, barbed points, which exhibit a narrow neck and a straight to convex base (Dyck 1983:105, Kehoe 1974:108-109, Peck 2011:236) similar to those present in the Pelican Lake composite assemblage. In the later stages of the series (2800-2000 B.P.) another point style, the Bracken projectile point is associated predominately with kill sites. This style is similar in morphology to the Classic variety of Pelican Lake points but differs as it is bulked up for communal hunting situations. It is described as broadly corner-notched with obtuse shoulders and wide necks, (Kehoe 1974:111, Peck 2011:256-257) generally exhibiting straight to convex bases. The appearance of the Bracken point style marks the beginning of large scale communal hunting on the Northern Plains by Pelican Lake peoples. Bracken points are represented in this study by the Smyth site assemblage. The requirement for a larger more robust projectile point better designed for communal hunting was established previously in this chapter. As such the Classic Pelican Lake point is rather fragile. Breaks exhibited through the stem, or base of the projectile point are common in the Walter Felt and other surface collected assemblages. These points were all deeply notched and barbed suggesting that the design although well developed for solitary hunting or smaller game was ill-equipped for communal hunting of larger game.

The predominant game species (such as mountain sheep and mule deer) in the montane regions of the Northwestern Plains may reflect the Classic Pelican Lake point design as designed for solitary hunting and smaller game. This would suggest that as the cultural manifestation became more adapted to the larger game of the Plains and especially to communal hunting of that larger game a new more robust style of point was required. This heavier style of point is represented by projectiles from the Smyth site in this study and this change is noted by other authors (Dyck 1983) as is its appearance at other kill assemblages (Peck 2011).

With this in mind, it is the opinion of this author that the Classic Pelican Lake points present throughout the series represent a point designed for smaller game and solitary hunting. In these situations projectile retention in the animal would be highly desired. The Bracken point appearing later represents a heavier point which is designed to operate in communal hunting settings of larger game. Both of these morphologically different point styles seem to be utilized by the same cultural group/entity and represent different pieces of the Pelican Lake tool kit.

The Intermediate Series (2500-2000 B.P.) is comprised of two point styles; Outlook points, side-notched with broad “u” or “v” shaped notches, generally straight based but may exhibiting a slight basal concavity (>1mm) (Dyck and Morlan 1995:437) and Bratton points either corner or side-notched with a convex base, in which the depth of the convexity is greater that 1mm but less than 7mm (Dyck and Morlan 1995:379). The Intermediate Series may date as early as 3000 B.P. and extend to 1300 B.P. as that is the time span of the Bratton point as defined by Dyck and Morlan (1995:379). However, as previously noted the dates used to define the Intermediate series are those proposed by Dyck and Morlan (1995) to define the early beginnings of the Besant Complex. The Intermediate Series, at least on the Saskatchewan Plains seems also to contain pottery as cultural level 3 at the Meewasin Site (FbNp-9) contained three (3) pottery sherds in association with an Outlook projectile point and a date of 2130±125 B.P. (S-2366) (Frary 2009:156, CARD 2013). The points associated with the Naze Site’s (32SN246) early pottery (Gregg 1987:259 Figure 8.2, Gregg and Picha 1989:50 Figure 2) would not look out of place next to the points from the Crane X assemblage or the Bratton assemblage. With a date ranging from 2388±44 to 2472±45 B.P. (SMU-1759 & SMU-1761) (Gregg 1987, Gregg and Picha 1989) and the presence of some larger side-notched and possible Bratton points at this site would seem to fit well within the Intermediate Series.

This early start date for this point style does not suggest that Besant’s origins lie in the evolution out of Pelican Lake, but that regional cultural variation in some parts of Saskatchewan among Pelican Lake groups may have started prior to the arrival of Besant. Bratton points, as noted by Dyck and Morlan (1995), are commonly found along with corner-notched Pelican Lake points, and as noted in the Crane X assemblage can also be found with more side-notched “Besant” style points. These mixed assemblages postdate the earliest Besant assemblages by several centuries. They show an interaction between late Pelican Lake and Besant and may represent a heavy influence of some regional late Pelican Lake groups by Besant.

The current interpretation of the Besant Complex (2500-1200 B.P.) remains very similar to its description in earlier works (Dyck 1983, Hjermstad 1996, Reeves 1983) and is seen as an Eastern Woodlands group or influence expanding onto the Plains. The only difference from these interpretations of the Besant Complex is the earlier time depth proposed by this thesis. It contains a single point style that was reviewed in this thesis: the Besant side-notch. It is described as side-notched with broad shallow notches and a slightly concave base (Peck 2011:307, Wettlaufer 1955:44). The point style present at kill sites mimics the point style present at the camp/habitation sites it is just more robust, morphologically they appear to be the same. Slight variations seem to be present through time. Some of the older assemblages contain points with slightly deeper basal concavities, previously called Sandy Creek points. Elongated projectile points made of Knife River Flint have been referred to as Sonota. Both these point styles, (as shown by the Besant/Fitzgerald/ and Fincastle assemblages) however, fit well within the range of variation presented by later Besant assemblages, and do not exist as a separate entities.

The other style of Besant projectile point that was not analyzed in this study is the Samantha point. It was not studied as the focus of the research was on earlier “Besant” and “Pelican Lake” projectile points and the stratigraphic unit they were from was considered mix (Walter Felt level 10). Samantha points are described as shallowly side-notched with slight basal concavities (Kehoe 1974). They are smaller than Besant side-notched points and are believed to be associated with the bow and arrow. Whether they are morphologically different from the larger Besant side-notched style is beyond this study and as such will remain tentatively within the Besant Complex.

The adoption of the bow and arrow in Saskatchewan and Alberta would not seem to be as rapid as was the case elsewhere. This may be due to the size of the large game hunted on the Northern Plains and the nature of that hunting. The presence of larger, robust points in the kill site assemblages would suggest the avoidance of the usage of the bow and arrow at these sites. The variation seen in the Intermediate Series of projectile points and the earlier Besant camp/habitation sites is likely a result of the technological learning curve as larger older successful dart tips were fastened to smaller arrow shafts.

Chapter 7
Summary and Conclusions

7.1 Summary of Analysis

This thesis sought to clarify a period of the archaeological record on the Northern Plains that was supposedly witness to a level of regional projectile point variation not seen since the beginning of the Early Middle Period. As many as fourteen (14) different projectile point varieties have been named and assigned to the Terminal Middle/Transitional Late Period by several authors (Dyck 1983, Dyck and Morlan 1995, Kehoe 1974, Peck 2011, Wettlaufer 1955). Over the course of this project 291 projectile points were analyzed, of which 174 were considered complete enough for geometric morphometrics analysis. These projectile points represented twelve (12) assemblages from nine (9) archaeological sites, which were placed by the previous authors into one or two of the previously noted point styles.

This study focused on the morphology of the projectile points from the distal portion of the notch opening to the proximal end of the point basically the basal morphology. This was done as this portion of a point is the least affected by the rejuvenation process (Walker 1992:135, Varsakis 2006:128). The work presented here reduced the numerous point styles to five (Classic Pelican Lake, Bracken, Besant side-notched, Outlook, and Bratton); these will be explained below. It is the hope that studies such as this one can take some of the subjectivity out of certain aspects of archaeology that rely on the highly visual.

The results of the research aims of the thesis are briefly outlined below. To answer the first research aim; as to whether the point classification used on the Canadian Plains supported by geometric morphometric testing, the short answer is no, although none of the cultural chronologies based on projectile points are inherently wrong, none are right either. Dyck and Morlan's (1995) work seems to be closest to the findings of this study. A proposed revised cultural chronology based on projectile points was presented in the previous chapter and is outlined further below.

The second research aim was to determine whether the projectile points associated with these assemblages could be assigned metrically to a known typology, and if not, where did they fit within the Plains point chronology. This was easier to achieve than the first aim. The Pelican Lake composite assemblage and the Smyth assemblage were grouped together into the Pelican

Lake Series. The term series was employed to respond to the chronological seriation of point styles. The Sandy Creek and Besant composite assemblages along with the Fitzgerald, the Fincastle, Walter Felt 13c, and the Walter Felt 15a assemblages were all grouped together into the Besant Complex. These assemblages shared the most morphological traits as defined by the locations of the landmarks, and the difficulty in which the discriminate function analysis portrayed in separating these assemblages. The Bratton and Crane X assemblages were the most intertwined shape wise and were grouped together as Bratton assemblages. The Outlook assemblage was significantly different from all the other assemblages with the exception of the Rocky Island assemblage which was similar to the Bratton and Crane X assemblages, allowing for a possible connection between Bratton and Outlook to be established.

The third research aim involved determining whether the projectile points styles represnted a regional adaptation to the bow and arrow and if this was responsible for the projectile point variation seen during this period. This was answered through the metric testing. This testing showed an increase in the ratio of points returning the results of arrow or no decision in relation to the camp/habitation site assemblages most similar to those of the Intermediate Series and the Pelican Lake composite group. The kill site assemblages associated with Pelican Lake and Besant had the largest dart vs arrow scores of the projectile points that were subjected to metric testing. This would suggest that both site function and the adoption of the bow and arrow were responsible for the variation seen in the projectile points from this period.

As a result of addressing these research questions a revised culture chronology was proposed. It is markedly similar to the one proposed by Dyck and Morlan (1995). The Pelican Lake Series (3600-2000 B.P.) is comprised of two corner-notched point styles: (1) Classic Pelican Lake points which are present throughout assemblages in the series and (2) Bracken points which appear later in the series and are confined for the most part to kill site assemblages. The Classic Pelican Lake points are likely smaller atlatl dart points designed for hunting more diverse game. Bracken points represent larger atlatl points utilized in the communal hunting of larger game (i.e. Bison).

The Besant Complex (2500-1200 B.P.) is comprised of Besant side-notched points (which were analyzed in this thesis), and possibly Samantha side-notched points (which were not analyzed). Besant side-notched points are present in both kill and camp/habitation site assemblages. The Besant side-notched points are largely atlatl dart points with the possibility of a few smaller specimens being arrow points.

The Intermediate Series (2500-2000 B.P.) may extend deeper into the past than is presented here. However, for the present this transitional period should remain within the time span suggested by Dyck and Morlan (1995). The Intermediate Series may represent local Pelican Lake groups slowly developing point styles similar to those in the Besant Complex, in order to facilitate large scale communal hunting. The Intermediate Series is comprised of two projectile point styles: (1) corner/side-notched Bratton points which occur throughout the series and seem to largely represent large and small atlatl points and (2) a small side-notched style found only in the earlier portion of the series and is referred to as Outlook. Outlook points seem to represent small atlatl points or possibly (early) arrow points.

7.2 Future Directions of Study

The field of geometric morphometrics (GMM) opens a plethora of study avenues to an archaeologist. The ability to track morphological change of almost any artifact or assemblage from projectile points (Buchanan 2005; Buchanan et al 2007; Buchanan and Collard 2010; Buchanan et al 2012, Cardillo 2010; Iovita 2011; Lenardi and Merwin 2010), to bifaces (Iovita 2011), to pottery (Martinez-Carrillo et al 2010), to net weights (Cardillo 2010), to faunal analysis (Kovarovic et al 2011), early domestication (Ottoni et al 2013), fossil hominin and evolutionary studies (Gómez-Robles et al 2007; Singh et al 2012), even as far as the possibility of automating or aiding in artifact analysis (Barceló 2010; Lenardi and Merwin 2010), makes GMM a highly useful analytical tool. The above is not an exhaustive list but shows the wide range of research possibilities capable with a GMM approach. As mentioned previously in this thesis and elsewhere (Lenardi and Merwin 2010; Martinez-Carrillo et al 2010), researcher subjectivity and subjective terminology is something that has plagued archaeology since its inception. Geometric morphometrics offers a way to standardized quantitative artifact analysis and in this process reduce the vague and cloudy qualitative language that follows it. One area where GMM may be less effective is in regards to objects that are separated based on traits that do not alter shape. This is due to the features commonly analyzed or reported on such as pottery ware decoration which usually does not impact shape.

With this in mind a review of a wider range of artifacts from the assemblages studied here and others may detect underlying similarities or differences between assemblages not seen in the larger projectile point variation. The framework of this thesis could be built upon by looking at the shape differences of other stone tools, and of bone tools if present, this would increase our understanding of the assemblages and larger phases and complexes. Perhaps a GMM analysis of a wider range of tools may lead to stronger interpretations of Reeves' (1983) often neglected cultural traditions, possibly linking or unlinking complexes and phases.

The findings of this research have suggested several trends in this data; these trends may be better expressed or obscured with more data. The current variability of some of these assemblages is influenced by the small sample size presented by them. By expanding the scale of a study to include more assemblages both within and beyond Saskatchewan and Alberta these sample size issues would more than likely be resolved. With larger samples the variability decrease and a more concise picture of projectile point morphology may present itself. Beyond increasing the sample sizes, this could also allow identification of the originating locations of artifact morphologies and the cultures that carried them. This would ultimately shed more light on the origins of Oxbow, McKean, Pelican Lake, Avonlea, or tracking point changes within the Mummy Cave Series.

On the basis of the data presented in the previous chapter there seems to be a link between communal hunting and point size and shape. Further study may lead to new insights into how this style of hunting affected the spread of technology on the Northern Plains. A more encompassing study of kill and camp/habitation sites would provide additional information to form a more complete picture of the impact of communal hunting on technology. A study of this nature would go hand in hand with further sorting out the morphological differences between Pelican Lake/Bracken and if they are indeed related to hunting practises and game size as is suggested here.

This thesis shows but one of the many ways geometric morphometrics can be used. The projectile point analysis undertaken here is a method in which many of the subjective qualities and measurements can be tested to obtain a more objective representation of projectile point morphology. The opportunities presented from using this approach would allow for greater understanding of many factors that influence the shape change in artifacts. The potential of geometric morphometrics and its application in archaeology is unbounded.

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Appendix A: Results of the Canonical Variate Analysis on Assemblages

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Table A.1 Assemblages and Composition Used in the CVA.

Groups	Assemblage	Observations
1.	Besant	9
2.	Bratton	2
3.	Crane X	9
4.	Fincastle	41
5.	Fitzgerald	37
6.	Outlook	5
7.	Pelican Lake	11
8.	Rocky Island	2
9.	Sandy Creek	5
10.	Smyth	38
11.	Walter Felt 13c	6
12.	Walter Felt 15a	9

Table A.2 Variation among groups, scaled by the inverse of the within-group variation.

Canonical Variate	Eigenvalues	% Variance	Cumulative %
1.	2.68457733	69.418	69.418
2.	0.54584232	14.114	83.532
3.	0.34523183	8.927	92.459
4.	0.20808619	5.381	97.840
5.	0.06758344	1.748	99.588
6.	0.01595019	0.412	100.000

Table A.3 Mahalanobis distances among groups.

Assemblage	Besant	Bratton	Crane X	Fincastle	Fitzgerald	Outlook	Pelican Lake	Rocky Island	Sandy Creek	Smyth	Walter Felt 13c	Walter Felt 15a
Besant	0	2.6835	3.9315	1.3644	1.0271	2.5401	5.6574	2.8905	1.5395	3.1978	1.6029	1.454
Bratton	2.6835	0	2.571	2.7959	2.1097	3.5894	5.0766	3.0988	3.8252	3.3762	2.3482	3.1032
Crane X	3.9315	2.571	0	4.0238	3.3222	3.6017	3.1423	2.7417	4.8245	2.7169	2.664	3.7589
Fincastle	1.3644	2.7959	4.0238	0	1.339	2.7055	5.2172	3.4058	1.9707	2.934	1.664	1.014
Fitzgerald	1.0271	2.1097	3.3222	1.339	0	2.592	5.1766	2.9649	2.3133	2.7673	1.1257	1.2982
Outlook	2.5401	3.5894	3.6017	2.7055	2.592	0	4.9911	2.0306	2.3268	3.6556	2.4552	2.2432
Pelican Lake	5.6574	5.0766	3.1423	5.2172	5.1766	4.9911	0	4.5751	6.1429	2.9532	4.1461	4.8404
Rocky Island	2.8905	3.0988	2.7417	3.4058	2.9649	2.0306	4.5751	0	2.9886	3.3116	2.54	3.0685
Sandy Creek	1.5395	3.8252	4.8245	1.9707	2.3133	2.3268	6.1429	2.9886	0	3.8739	2.6005	1.886
Smyth	3.1978	3.3762	2.7169	2.934	2.7673	3.6556	2.9532	3.3116	3.8739	0	1.7667	2.4884
Walter Felt 13c	1.6029	2.3482	2.664	1.664	1.1257	2.4552	4.1461	2.54	2.6005	1.7667	0	1.2723
Walter Felt 15a	1.454	3.1032	3.7589	1.014	1.2982	2.2432	4.8404	3.0685	1.886	2.4884	1.2723	0

Table A.4 P-values from permutation tests for Mahalanobis distances among groups.

Assemblage	Besant	Bratton	Crane X	Fincastle	Fitzgerald	Outlook	Pelican Lake	Rocky Island	Sandy Creek	Smyth	Walter Felt 13c	Walter Felt 15a
Besant	1	0.0564	<.0001	0.0113	0.2497	0.0014	0.0001	0.0653	0.3097	<.0001	0.3088	0.186
Bratton	0.0564	1	0.1877	0.006	0.2089	0.005	0.0235	<.0001	0.0423	0.0018	0.4103	0.037
Crane X	<.0001	0.1877	1	<.0001	<.0001	0.0012	0.0008	0.1661	0.0001	<.0001	0.0154	<.0001
Fincastle	0.0113	0.006	<.0001	1	<.0001	<.0001	<.0001	0.0001	0.003	<.0001	0.0142	0.1822
Fitzgerald	0.2497	0.2089	<.0001	<.0001	1	0.0006	<.0001	0.0281	0.004	<.0001	0.3947	0.0694
Outlook	0.0014	0.005	0.0012	<.0001	0.0006	1	<.0001	0.3973	0.0604	<.0001	0.036	0.0289
Pelican Lake	0.0001	0.0235	0.0008	<.0001	<.0001	<.0001	1	0.0231	<.0001	<.0001	0.0001	<.0001
Rocky Island	0.0653	<.0001	0.1661	0.0001	0.0281	0.3973	0.0231	1	0.1893	0.0071	0.394	0.0148
Sandy Creek	0.3097	0.0423	0.0001	0.003	0.004	0.0604	<.0001	0.1893	1	<.0001	0.0629	0.1712
Smyth	<.0001	0.0018	<.0001	<.0001	<.0001	<.0001	<.0001	0.0071	<.0001	1	0.0221	<.0001
Walter Felt 13c	0.3088	0.4103	0.0154	0.0142	0.3947	0.036	0.0001	0.394	0.0629	0.0221	1	0.6159
Walter Felt 15a	0.186	0.037	<.0001	0.1822	0.0694	0.0289	<.0001	0.0148	0.1712	<.0001	0.6159	1

Table A.5 Procrustes distances among groups.

Assemblage	Besant	Bratton	Crane X	Fincastle	Fitzgerald	Outlook	Pelican Lake	Rocky Island	Sandy Creek	Smyth	Walter Felt 13c	Walter Felt 15a
Besant	0	0.1988	0.2471	0.0779	0.0716	0.1309	0.3045	0.1355	0.0907	0.1704	0.09	0.0717
Bratton	0.1988	0	0.1126	0.1938	0.1331	0.198	0.2654	0.1701	0.275	0.2134	0.1569	0.2024
Crane X	0.2471	0.1126	0	0.2376	0.1837	0.2173	0.1899	0.1737	0.3151	0.1897	0.1739	0.2302
Fincastle	0.0779	0.1938	0.2376	0	0.0837	0.131	0.2638	0.1582	0.1218	0.1492	0.084	0.0461
Fitzgerald	0.0716	0.1331	0.1837	0.0837	0	0.1241	0.2646	0.116	0.1515	0.1473	0.0569	0.0813
Outlook	0.1309	0.198	0.2173	0.131	0.1241	0	0.2775	0.0836	0.1395	0.2007	0.1307	0.1136
Pelican Lake	0.3045	0.2654	0.1899	0.2638	0.2646	0.2775	0	0.2605	0.3478	0.1591	0.2186	0.2528
Rocky Island	0.1355	0.1701	0.1737	0.1582	0.116	0.0836	0.2605	0	0.1689	0.177	0.1152	0.1343
Sandy Creek	0.0907	0.275	0.3151	0.1218	0.1515	0.1395	0.3478	0.1689	0	0.2198	0.1584	0.1074
Smyth	0.1704	0.2134	0.1897	0.1492	0.1473	0.2007	0.1591	0.177	0.2198	0	0.094	0.1287
Walter Felt 13c	0.09	0.1569	0.1739	0.084	0.0569	0.1307	0.2186	0.1152	0.1584	0.094	0	0.0669
Walter Felt 15a	0.0717	0.2024	0.2302	0.0461	0.0813	0.1136	0.2528	0.1343	0.1074	0.1287	0.0669	0

Table A.6 P-values from permutation tests for Procrustes distances among groups.

Assemblage	Besant	Bratton	Crane X	Fincastle	Fitzgerald	Outlook	Pelican Lake	Rocky Island	Sandy Creek	Smyth	Walter Felt 13c	Walter Felt 15a
Besant	1	0.0175	<.0001	0.0219	0.0469	0.0074	0.0001	0.0574	0.1719	<.0001	0.234	0.2894
Bratton	0.0175	1	0.4275	0.0012	0.0854	0.0139	0.0072	0.3428	0.0462	<.0001	0.2907	0.0386
Crane X	<.0001	0.4275	1	<.0001	<.0001	0.0004	0.0001	0.094	0.0001	<.0001	0.0165	0.0008
Fincastle	0.0219	0.0012	<.0001	1	<.0001	0.0015	<.0001	0.0108	0.0025	<.0001	0.0831	0.4347
Fitzgerald	0.0469	0.0854	<.0001	<.0001	1	0.0031	<.0001	0.1594	0.0006	<.0001	0.4162	0.0351
Outlook	0.0074	0.0139	0.0004	0.0015	0.0031	1	<.0001	0.4903	0.0773	<.0001	0.1611	0.1403
Pelican Lake	0.0001	0.0072	0.0001	<.0001	<.0001	<.0001	1	0.0099	<.0001	<.0001	0.0001	<.0001
Rocky Island	0.0574	0.3428	0.094	0.0108	0.1594	0.4903	0.0099	1	0.1826	0.0183	0.5755	0.2992
Sandy Creek	0.1719	0.0462	0.0001	0.0025	0.0006	0.0773	<.0001	0.1826	1	<.0001	0.1072	0.2193
Smyth	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0183	<.0001	1	0.0623	0.0004
Walter Felt 13c	0.234	0.2907	0.0165	0.0831	0.4162	0.1611	0.0001	0.5755	0.1072	0.0623	1	0.6095
Walter Felt 15a	0.2894	0.0386	0.0008	0.4347	0.0351	0.1403	<.0001	0.2992	0.2193	0.0004	0.6095	1

Table A.7 Canonical Coefficients.

Landmark Coordinates	CV1	CV2	CV3	CV4	CV5	CV6
x1	-4.6783	-2.9449	8.8266	1.9241	5.9535	-2.9392
y1	2.2346	7.2899	3.1871	-0.9493	2.1058	-1.0228
x2	4.3099	-2.1978	-5.6892	6.3073	-25.4378	4.9661
y2	-2.9611	-2.0317	-0.0455	8.4371	19.4229	-0.5680
x3	3.2752	-7.5393	-5.3519	-8.0017	16.0355	-11.6129
y3	4.1055	-11.3288	10.4598	-7.7066	-20.3033	2.1586
x4	2.7878	10.0232	-0.6507	-4.4939	6.0089	16.8527
y4	-14.3617	5.1398	-12.2609	-0.5934	-1.7322	6.2822
x5	-5.6946	2.6587	2.8651	4.2642	-2.5600	-7.2668
y5	10.9827	0.9309	-1.3405	0.8123	0.5067	-6.8500

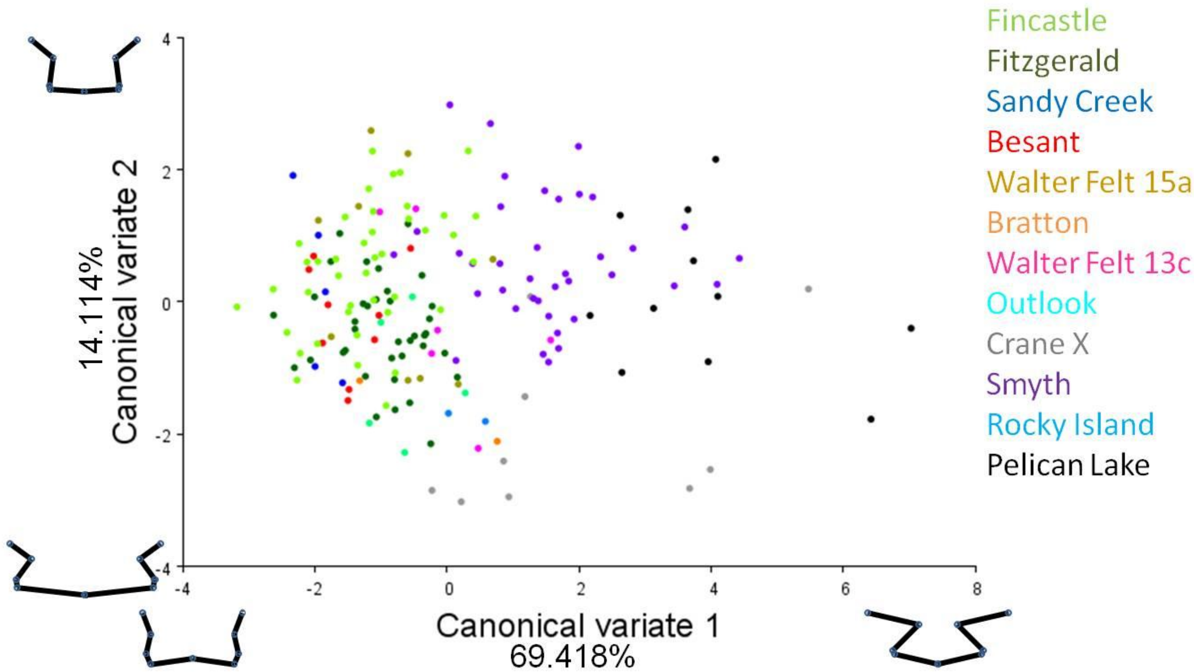

Figure A.1 CVA 1 against CVA 2.

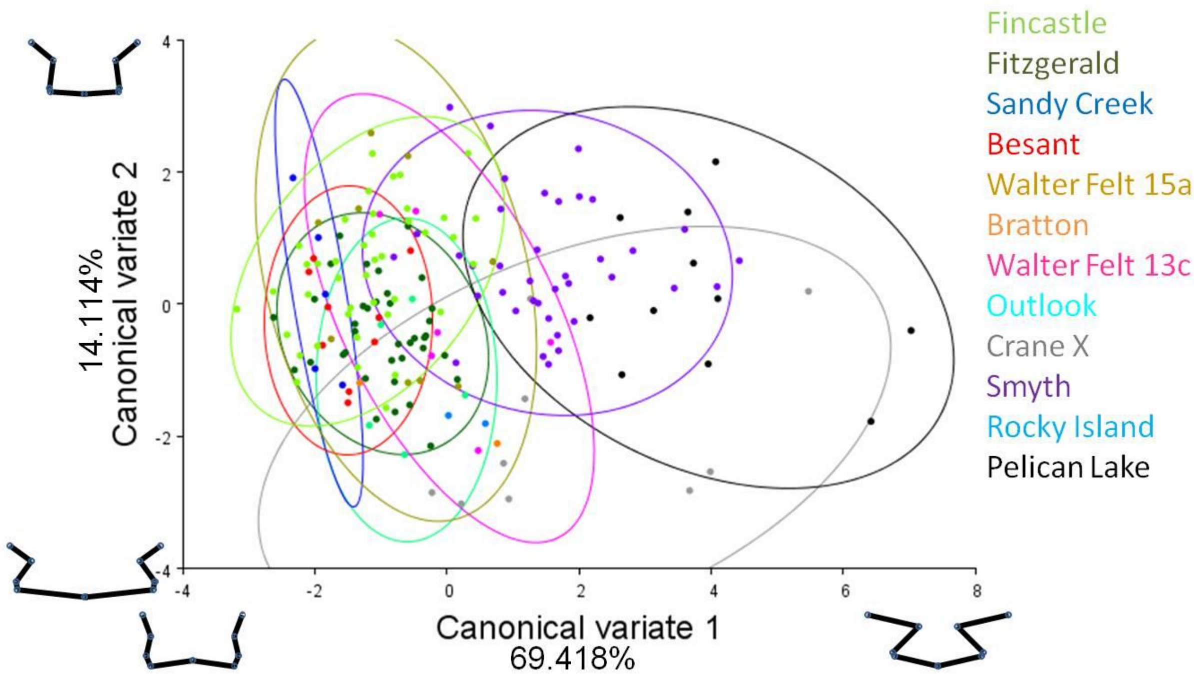

Figure A.2 CVA 1 against CVA 2 with 95% confidence ellipses around group means.

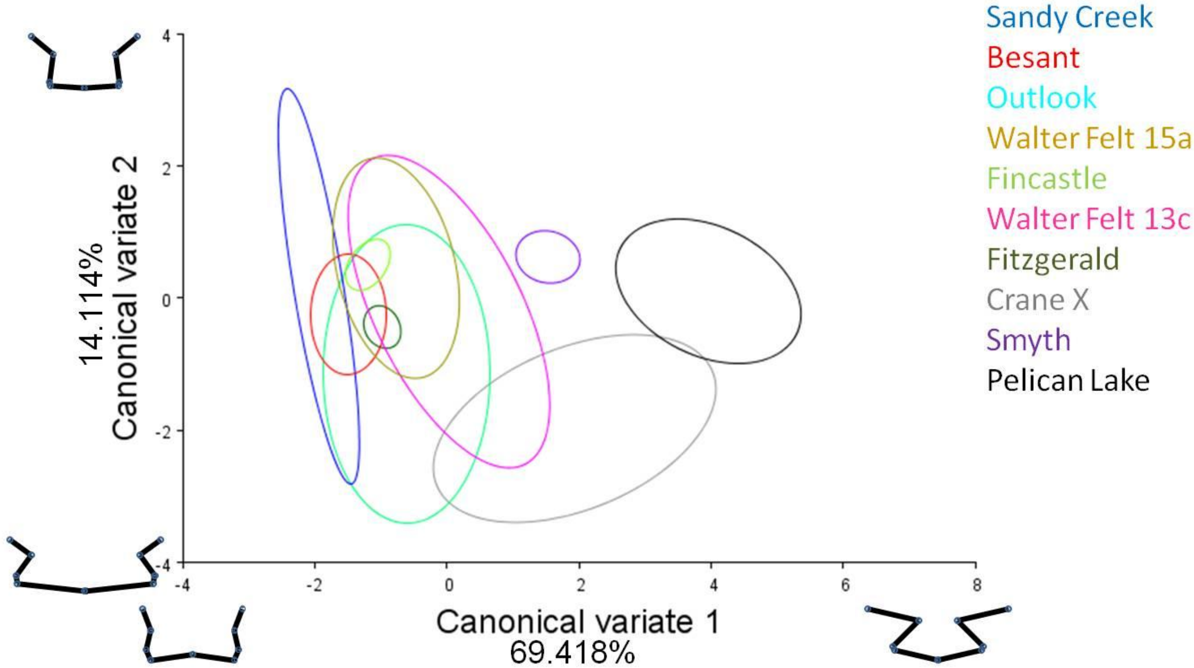

Figure A.3 CVA 1 against CVA 2 with ellipses around group means.

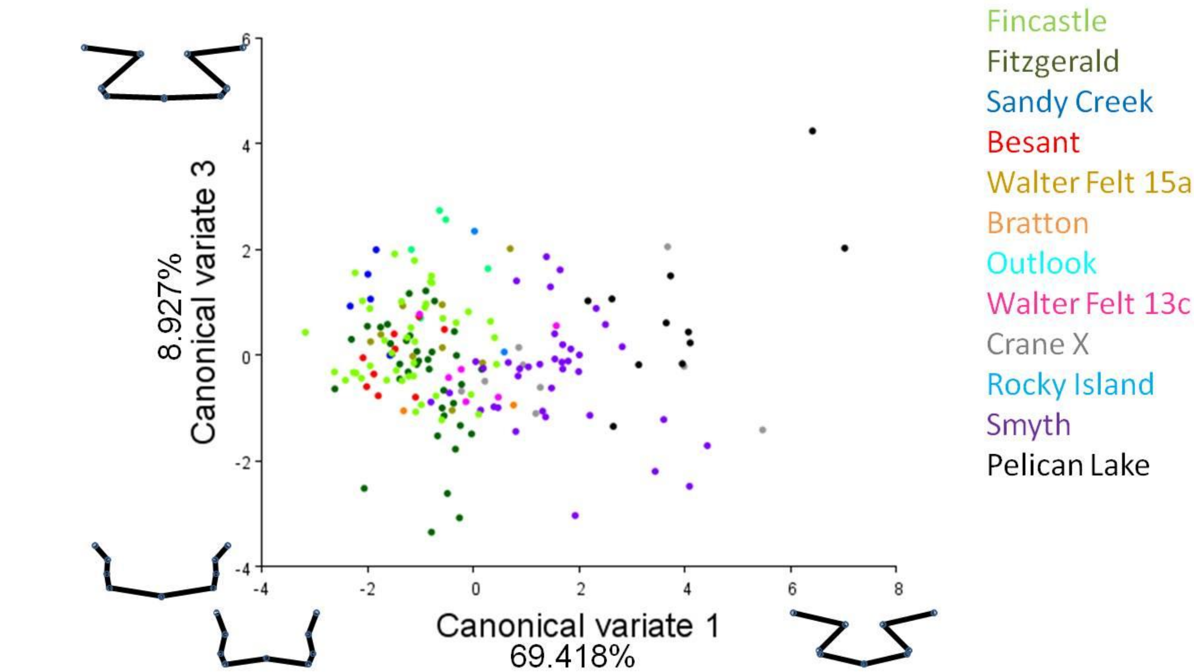

Figure A.4 CVA 1 against CVA 3.

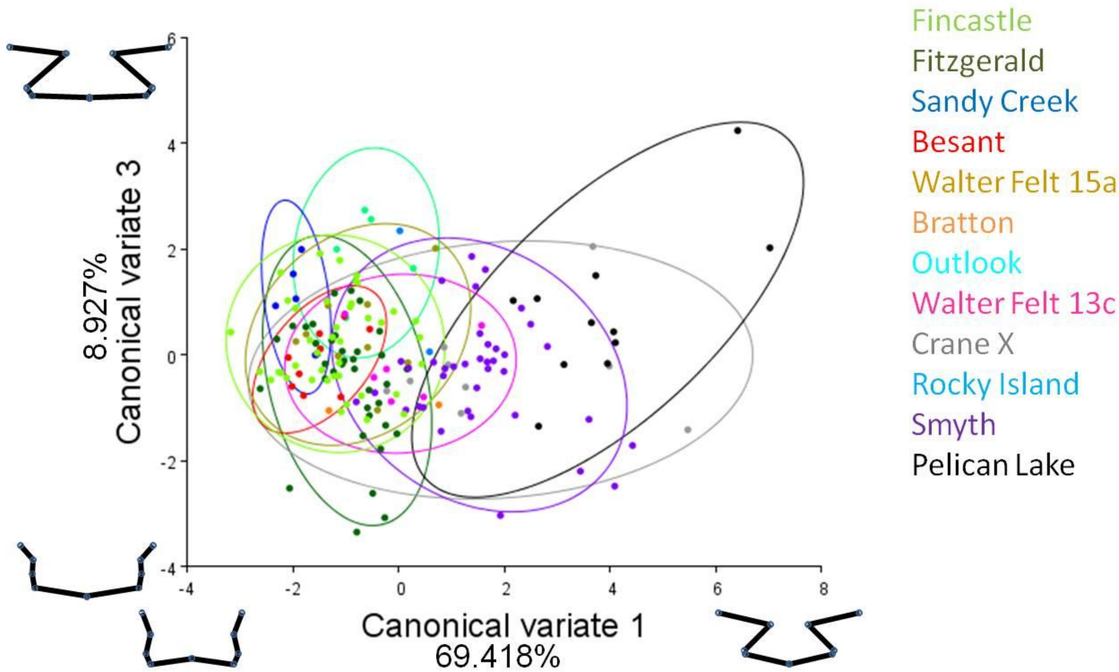

Figure A.5 CVA 1 against CVA 3 with 95% confidence ellipses around group means.

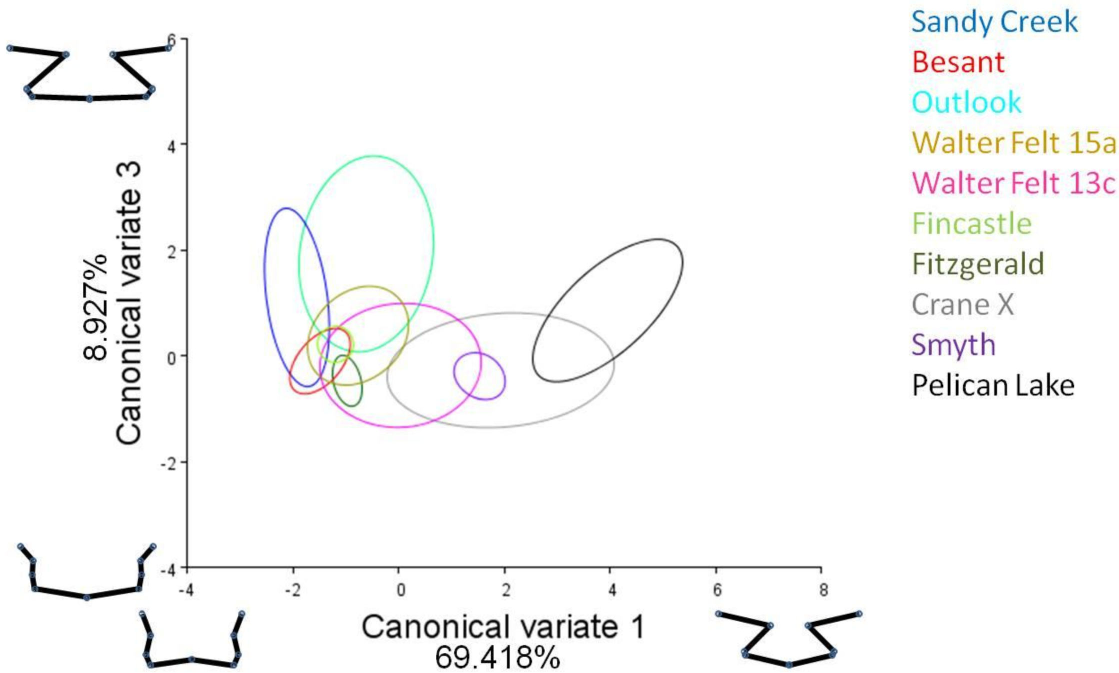

Figure A.6 CVA 1 against CVA 3 with ellipses around group means.

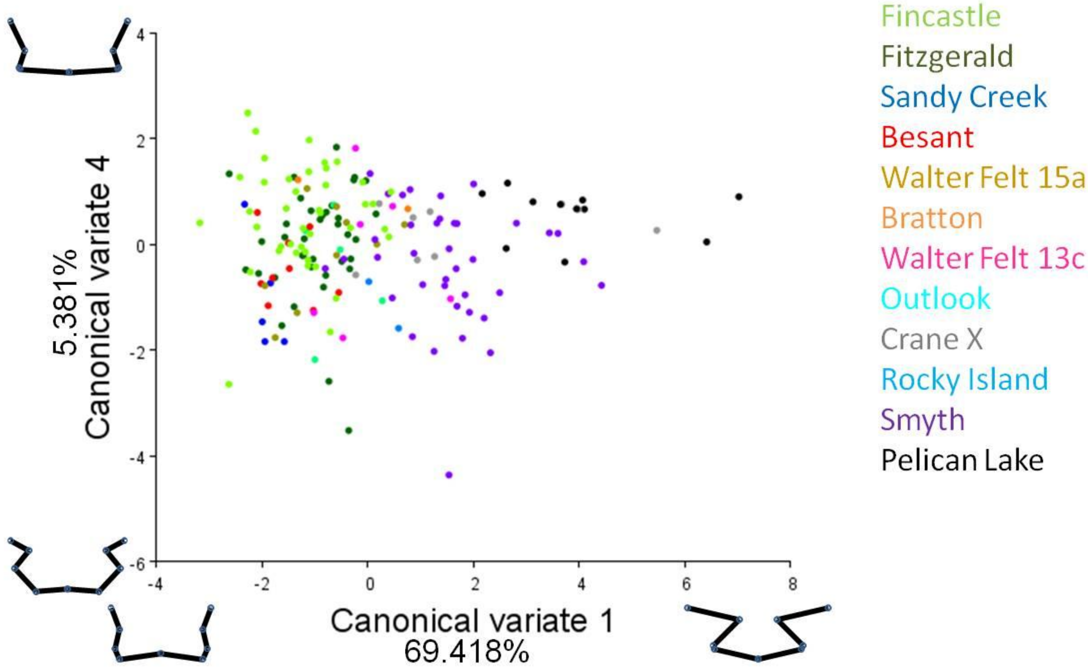

Figure A.7 CVA 1 against CVA 4.

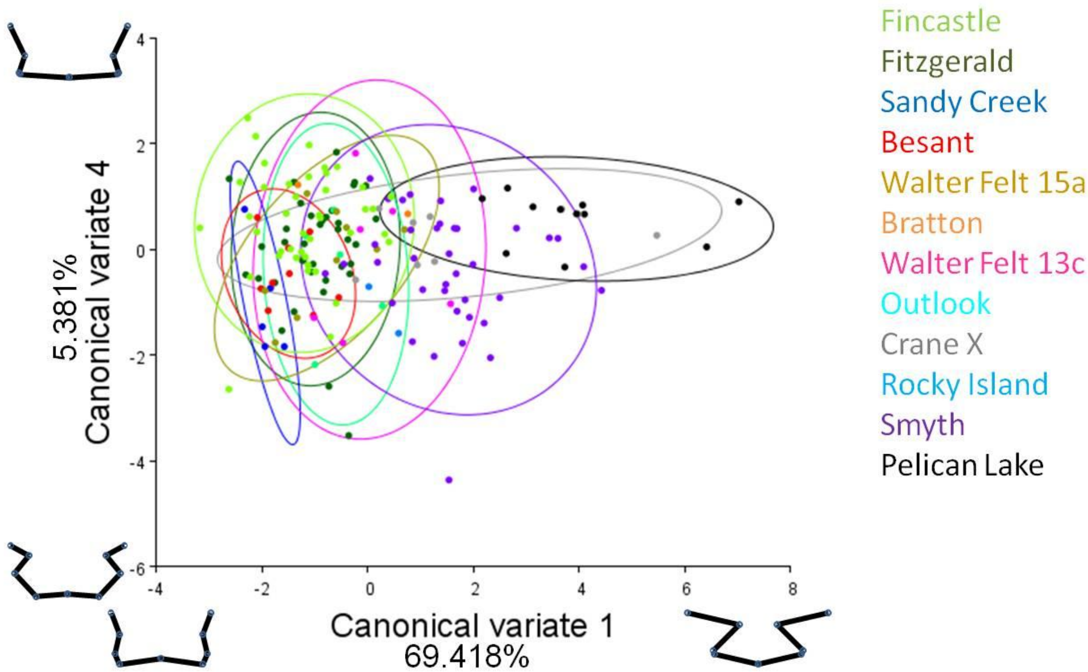

Figure A.8 CVA 1 against CVA 4 with 95% confidence ellipses around group means.

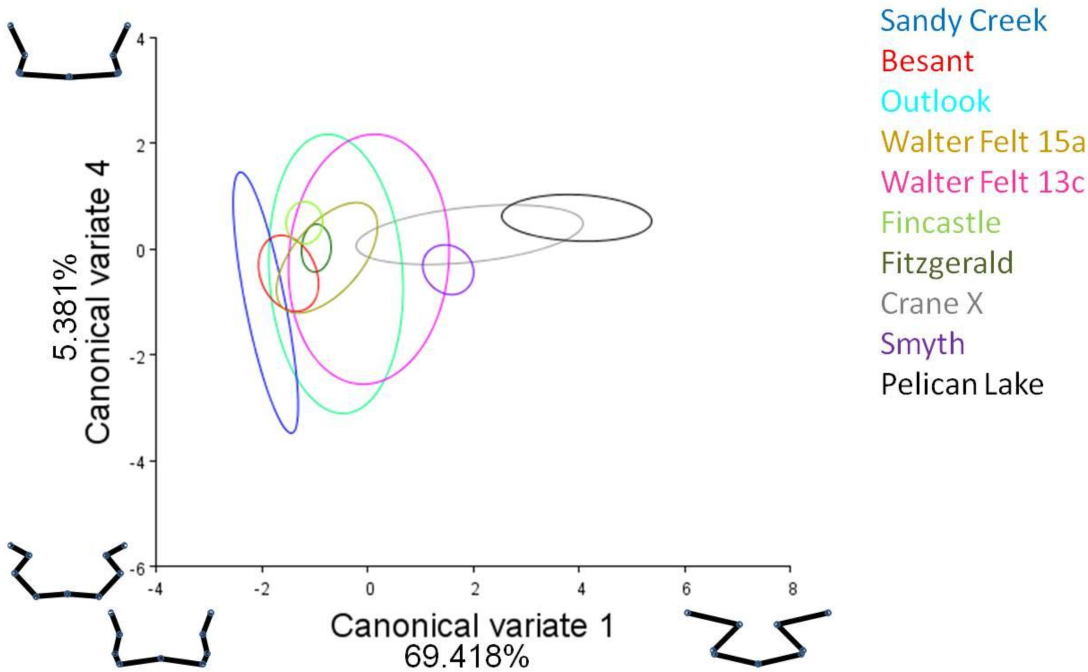

Figure A.9 CVA 1 against CVA 4 with ellipses around group means.

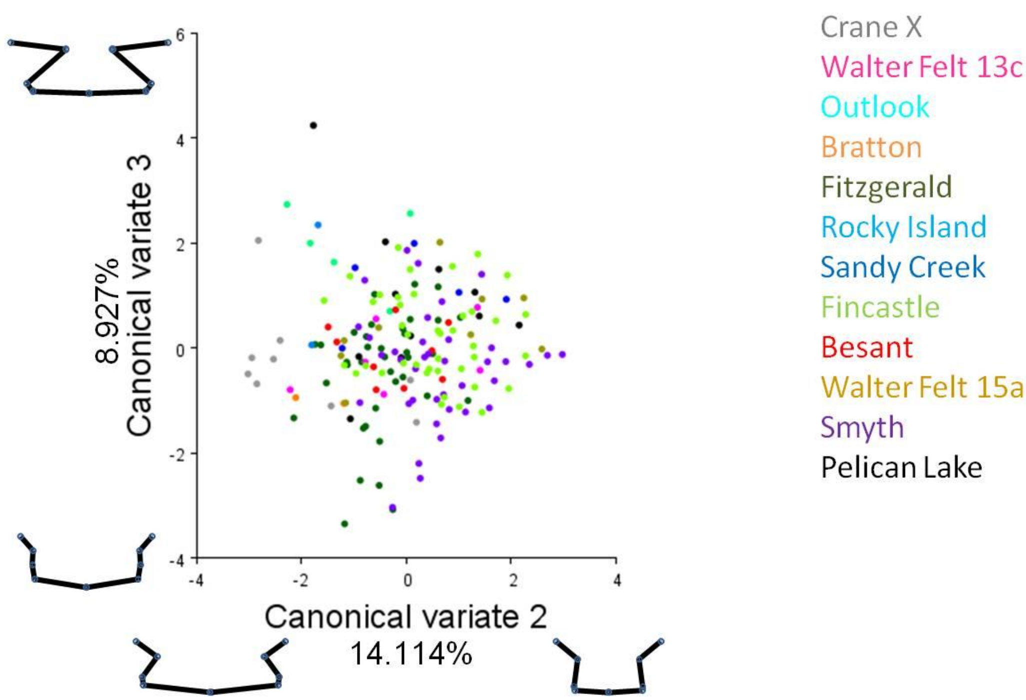

Figure A.10 CVA 2 against CVA 3.

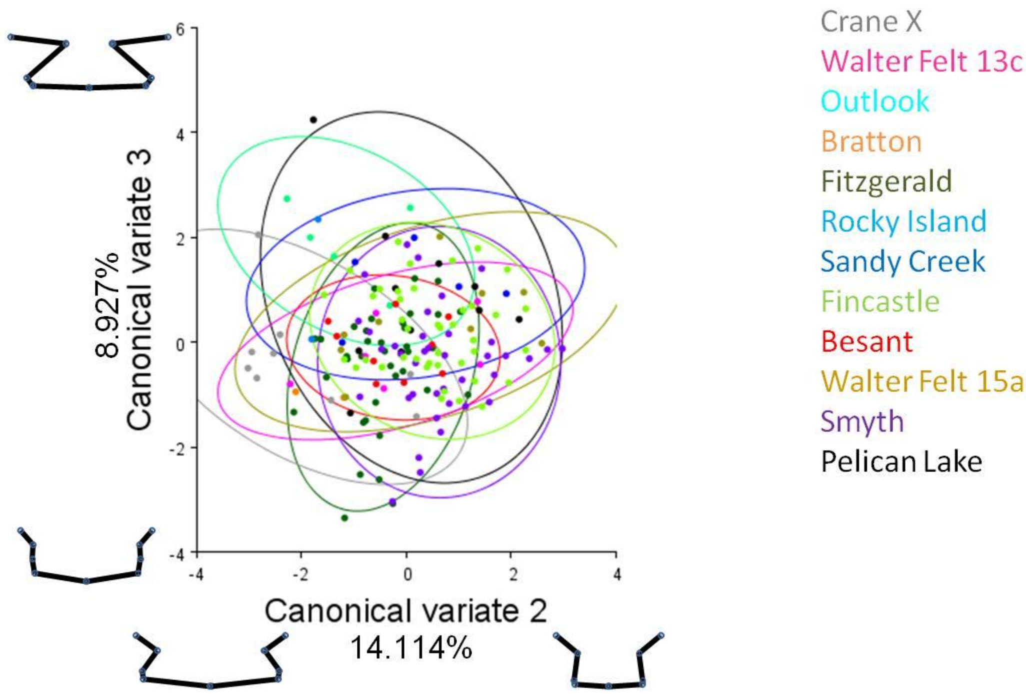

Figure A.11 CVA 2 against CVA 3 with 95% confidence ellipses around group means.

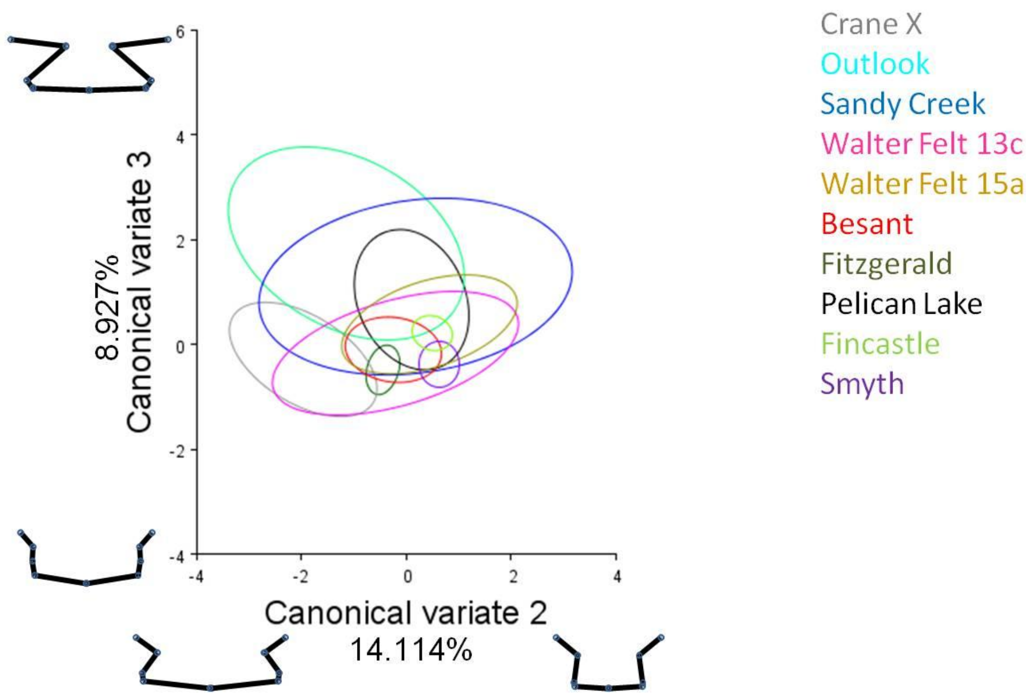

Figure A.12 CVA 2 against CVA 3 with ellipses around group means.

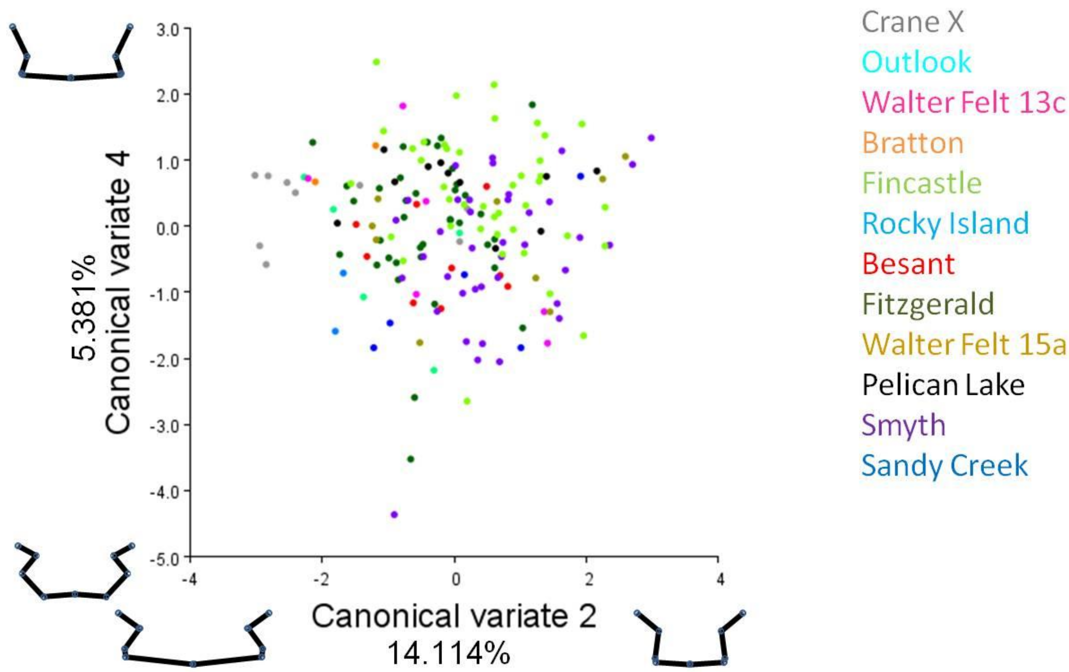

Figure A.13 CVA 2 against CVA 4.

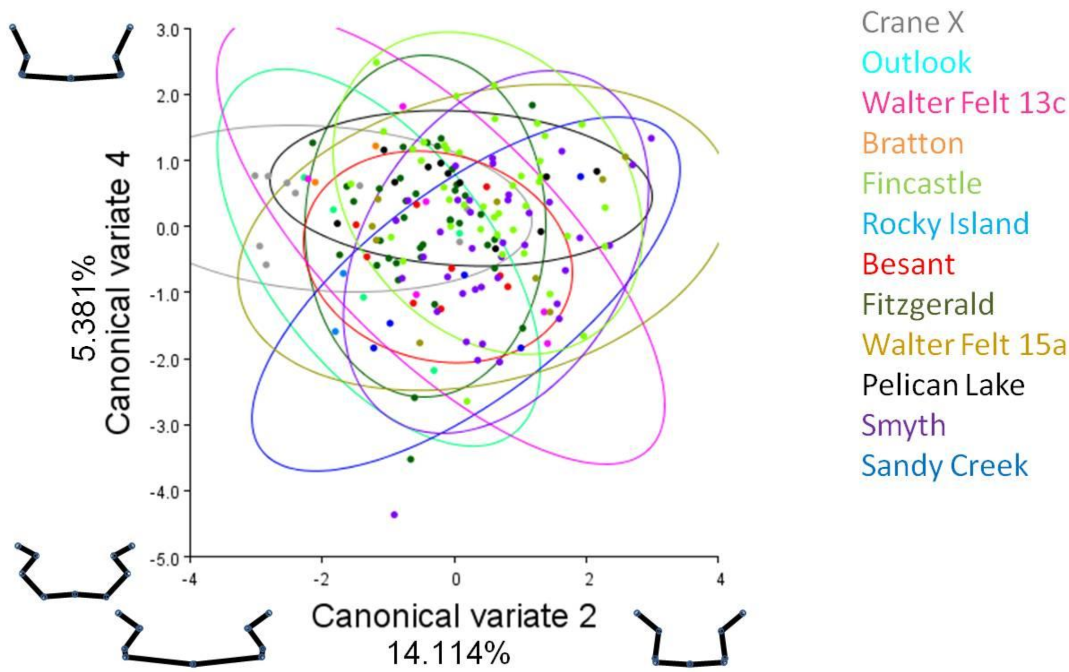

Figure A.14 CVA 2 against CVA 4 with 95% confidence ellipses around group means.

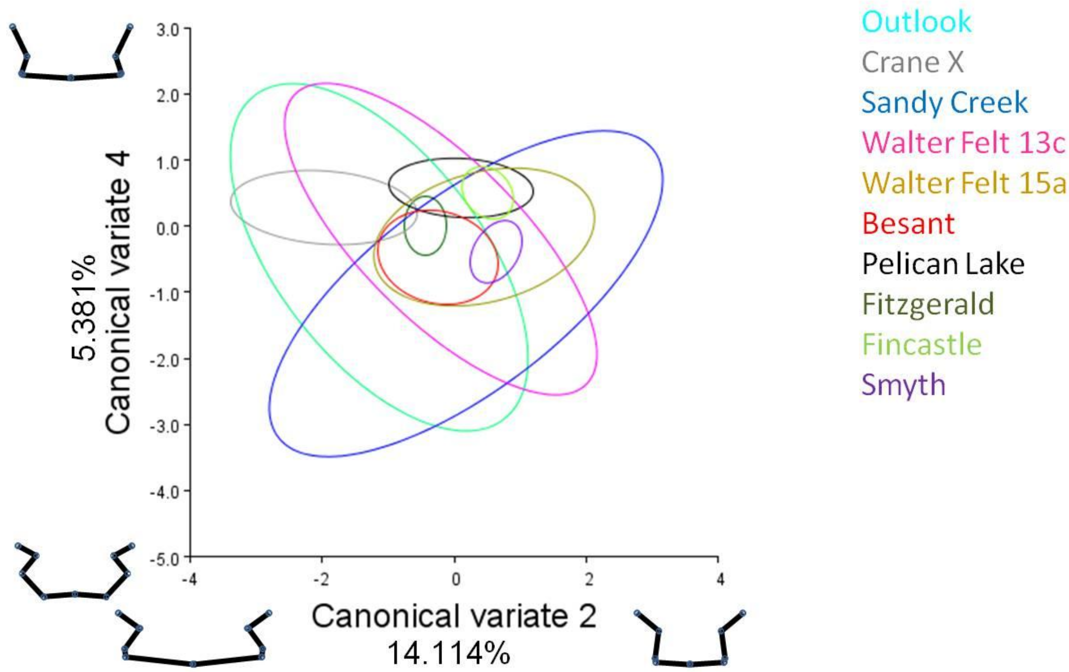

Figure A.15 CVA 2 against CVA 4 with ellipses around group means.

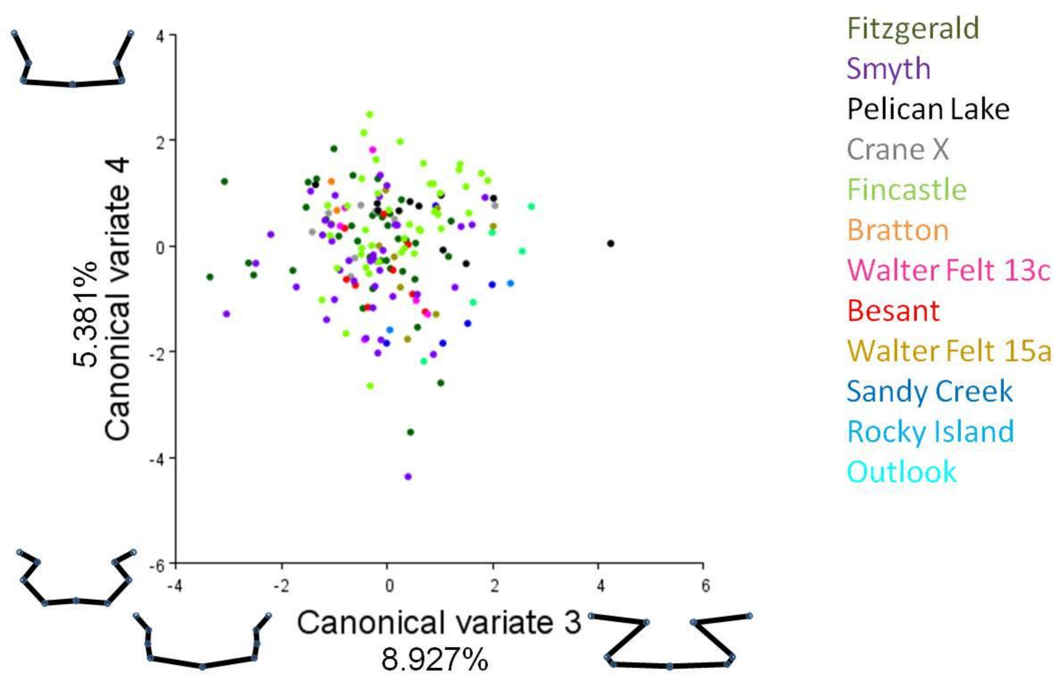

Figure A.16 CVA 3 against CVA 4.

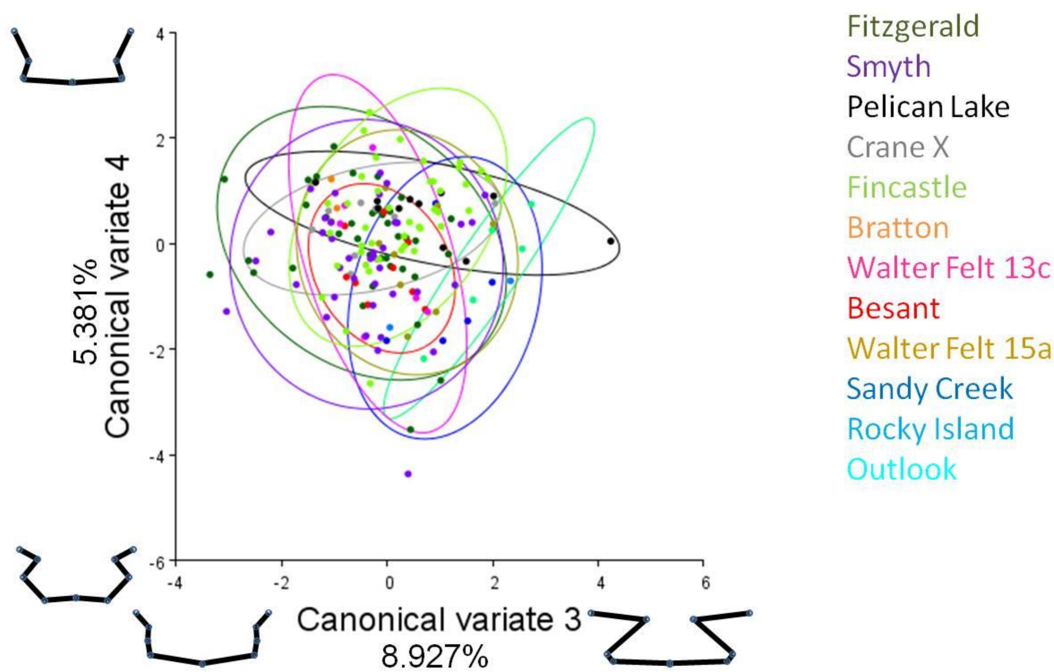

Figure A.17 CVA 3 against CVA 4 with 95% confidence ellipses around group means.

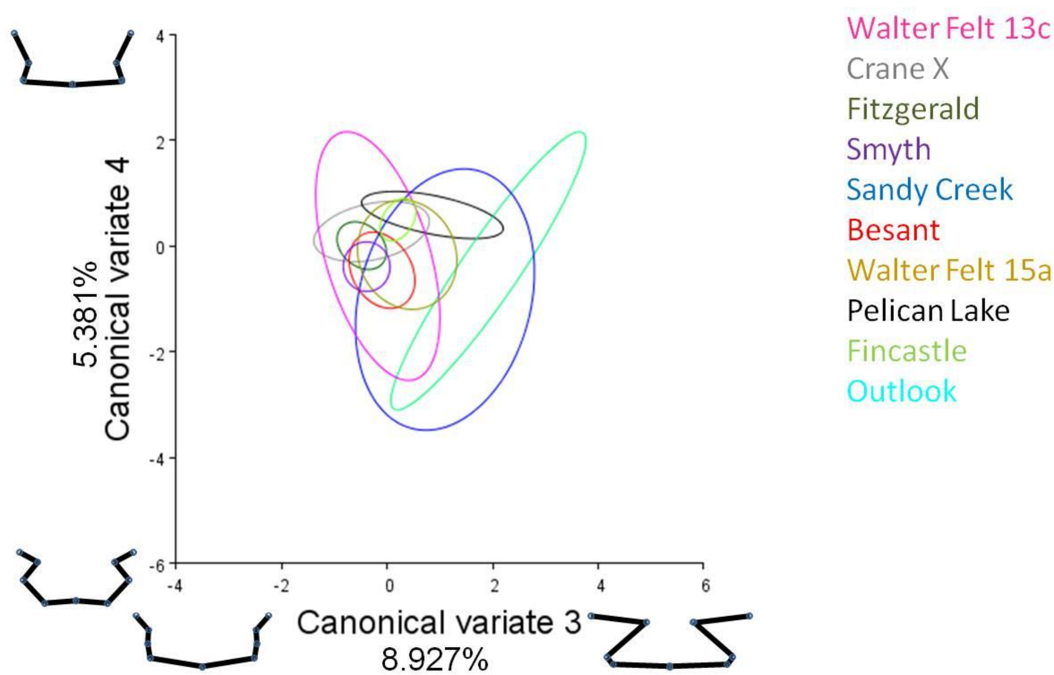

Figure A.18 CVA 3 against CVA 4 with ellipses around group means.

Appendix B: Results of the Discriminate Function Analysis on Assemblages

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Table B.1 Cross Validation Rates (per DFA comparison).

Assemblage	Besant	Bratton	Crane X	Fincastle	Fitzgerald	Outlook	Pelican Lake	Rocky Island	Sandy Creek	Smyth	Walter Felt 13c	Walter Felt 15a
Besant	x	63.9%	88.9%	64.4%	62.9%	84.4%	94.4%	33.3%	74.4%	89.2%	66.7%	61.1%
Bratton	63.9%	x	52.8%	71.3%	40.5%	65.0%	40.9%	25.0%	80.0%	73.7%	50.0%	38.9%
Crane X	88.9%	52.8%	x	94.4%	93.1%	88.9%	74.2%	27.8%	90.0%	86.3%	63.9%	72.2%
Fincastle	64.4%	71.3%	94.4%	x	72.9%	98.8%	100%	75.0%	75.1%	89.8%	58.1%	60.7%
Fitzgerald	62.9%	40.5%	93.1%	72.9%	x	85.9%	100%	70.9%	80.5%	93.4%	53.2%	54.7%
Outlook	84.4%	65.0%	88.9%	98.8%	85.9%	X	100%	20.0%	50.0%	84.7%	63.3%	58.9%
P. Lake	94.4%	40.9%	74.2%	100%	100%	100%	x	50.0%	100%	75.2%	82.6%	95.5%
R. Island	33.3%	25.0%	27.8%	75.0%	70.9%	20.0%	50.0%	x	60.0%	71.1%	75.0%	50.0%
S. Creek	74.4%	80.0%	90.0%	75.1%	80.5%	50.0%	100%	60.0%	x	87.4%	73.3%	78.9%
Smyth	89.2%	73.7%	86.3%	89.8%	93.4%	84.7%	75.2%	71.%	87.4%	x	61.8%	94.7%
WF 13c	66.7%	50.0%	63.9%	58.1%	53.2%	63.3%	82.6%	75.0%	73.3%	61.8%	x	55.6%
WF 15a	61.1%	38.9%	72.2%	60.7%	54.7%	58.9%	95.5%	50.0%	78.9%	94.7%	55.6%	x

Table B.2 Cross Validation scores (per assemblage).

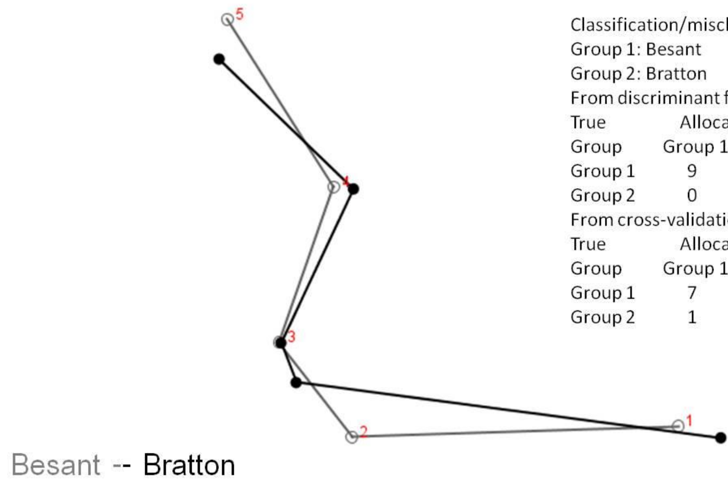
Assemblage	Besant	Bratton	Crane X	Fincastle	Fitzgerald	Outlook	Pelican Lake	Rocky Island	Sandy Creek	Smyth	Walter Felt 13c	Walter Felt 15a
Total in Assemblage	9	2	9	41	37	5	11	2	5	38	6	9
vs Besant	x	50.0%	88.9%	73.2%	70.3%	80.0%	100%	0.0%	60.0%	89.5%	66.7%	55.6%
vs Bratton	77.8%	x	55.6%	92.7%	81.1%	80.0%	81.8%	0.0%	60.0%	97.4%	50.0%	77.8%
vs Crane X	88.9%	50.0%	x	100%	97.3%	100%	81.8%	0.0%	80.0%	94.7%	50.0%	66.7%
vs Fin	55.6%	50.0%	88.9%	x	70.3%	100%	100%	50.0%	60.0%	86.8%	33.3%	55.6%
vs Fitz	55.6%	0.0%	88.9%	75.6%	x	80.0%	100%	50.0%	80.0%	89.5%	33.3%	44.4%
vs Outlook	88.9%	50.0%	77.8%	97.6%	91.9%	X	100%	0.0%	60.0%	89.5%	66.7%	77.8%
vs P. Lake	88.9%	0.0%	66.7%	100%	100%	100%	X	0.0%	100%	86.8%	83.3%	100%
vs R. Island	66.7%	50.0%	55.6%	100%	91.9%	40.0%	100%	x	20.0%	92.1%	100%	100%
vs S. Creek	88.9%	100%	100%	90.2%	81.1%	40.0%	100%	100%	x	94.7%	66.7%	77.8%
vs Smyth	88.9%	50.0%	77.8%	92.7%	97.3%	80.0%	63.6%	50.0%	80.0%	x	50.0%	100%
vs WF 13c	66.7%	50.0%	77.8%	82.9%	73.0%	60.0%	81.8%	50.0%	80.0%	73.7%	x	77.8%
vs WF 15a	66.7%	0.0%	77.8%	65.9%	64.9%	40.0%	90.9%	0.0%	80.0%	89.5%	33.3%	X

Table B.3 Overall percentages of correct classification based on DFA.

Besant	Bratton	Crane X	Fincastle	Fitzgerald	Outlook	Pelican Lake	Rocky Island	Sandy Creek	Smyth	Walter Felt 13c	Walter Felt 15a
75.8%	40.9%	77.8%	88.2%	83.5%	72.7%	90.9%	27.3%	69.1%	89.5%	57.6%	75.8%

Comparison: Besant -- Bratton

Difference between means:
Procrustes distance: 0.19877381
Mahalanobis distance: 4.6707
T-square: 35.6973, P-value (parametric): 0.1829
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0210
T-square: 0.2860



Classification/misclassification tables
Group 1: Besant
Group 2: Bratton

From discriminant function:

True Group	Allocated to Group 1	Allocated to Group 2	Total
Group 1	9	0	9
Group 2	0	2	2

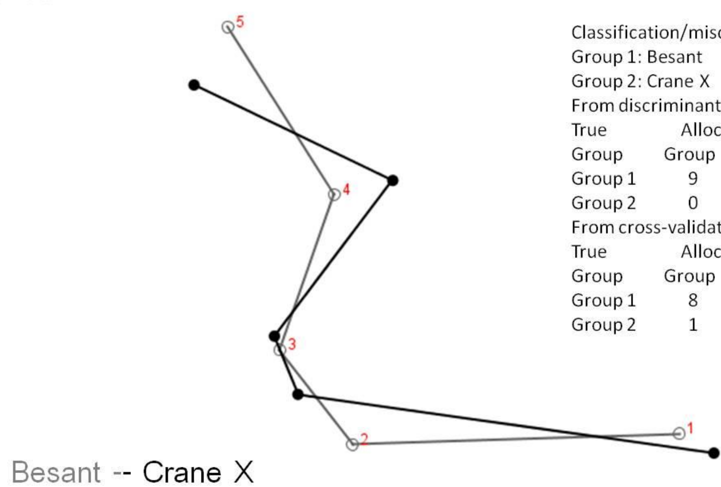
From cross-validation:

True Group	Allocated to Group 1	Allocated to Group 2	Total
Group 1	7	2	9
Group 2	1	1	2

Figure B.1 DFA Results between Besant (light) and Bratton (dark).

Comparison: Besant -- Crane X

Difference between means:
Procrustes distance: 0.24705352
Mahalanobis distance: 4.2366
T-square: 80.7712, P-value (parametric): 0.0009
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001



Classification/misclassification tables
Group 1: Besant
Group 2: Crane X

From discriminant function:

True Group	Allocated to Group 1	Allocated to Group 2	Total
Group 1	9	0	9
Group 2	0	9	9

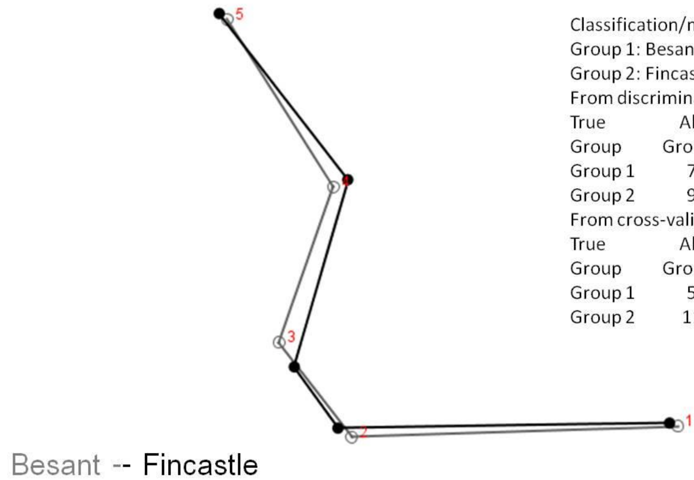
From cross-validation:

True Group	Allocated to Group 1	Allocated to Group 2	Total
Group 1	8	1	9
Group 2	1	8	9

Figure B.2 DFA Results between Besant (light) and Crane X (dark).

Comparison: Besant -- Fincastle

Difference between means:
Procrustes distance: 0.07785306
Mahalanobis distance: 1.6434
T-square: 19.9325, P-value (parametric): 0.0161
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0190
T-square: 0.0160



Classification/misclassification tables
Group 1: Besant
Group 2: Fincastle
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	7	2	9
Group 2	9	32	41

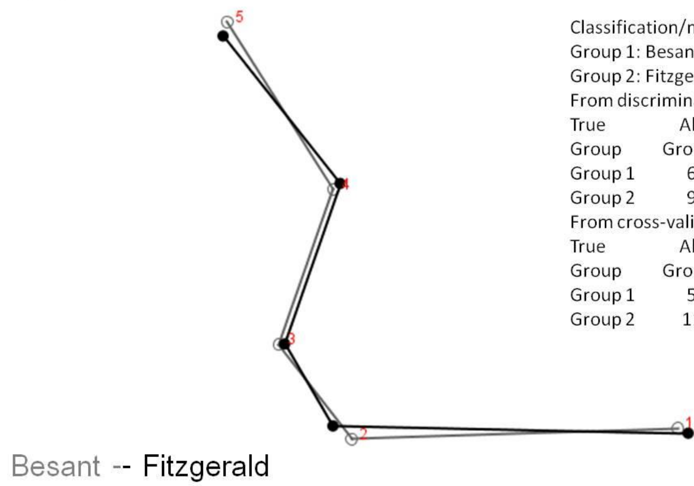
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	5	4	9
Group 2	11	30	41

Figure B.3 DFA Results between Besant (light) and Fincastle (dark).

Comparison: Besant -- Fitzgerald

Difference between means:
Procrustes distance: 0.07159749
Mahalanobis distance: 1.4531
T-square: 15.2864, P-value (parametric): 0.0576
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0440
T-square: 0.0470



Classification/misclassification tables
Group 1: Besant
Group 2: Fitzgerald
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	6	3	9
Group 2	9	28	37

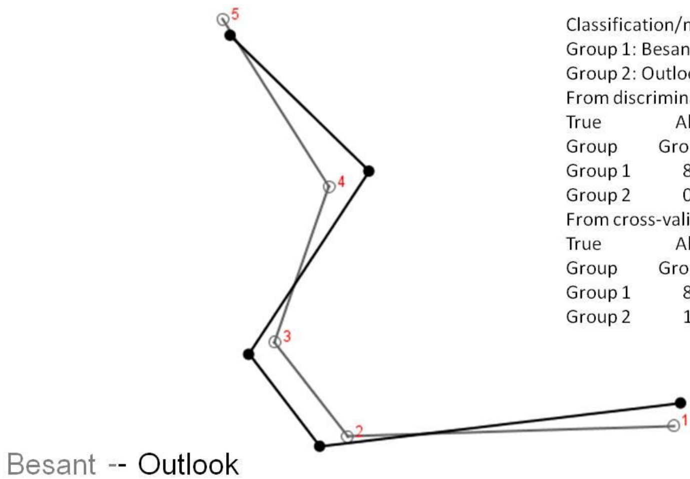
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	5	4	9
Group 2	11	26	37

Figure B.4 DFA Results between Besant (light) and Fitzgerald (dark).

Comparison: Besant -- Outlook

Difference between means:
Procrustes distance: 0.13091148
Mahalanobis distance: 3.7877
T-square: 46.1139, P-value (parametric): 0.0350
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0050
T-square: 0.0410



Classification/misclassification tables
Group 1: Besant
Group 2: Outlook
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	8	1	9
Group 2	0	5	5

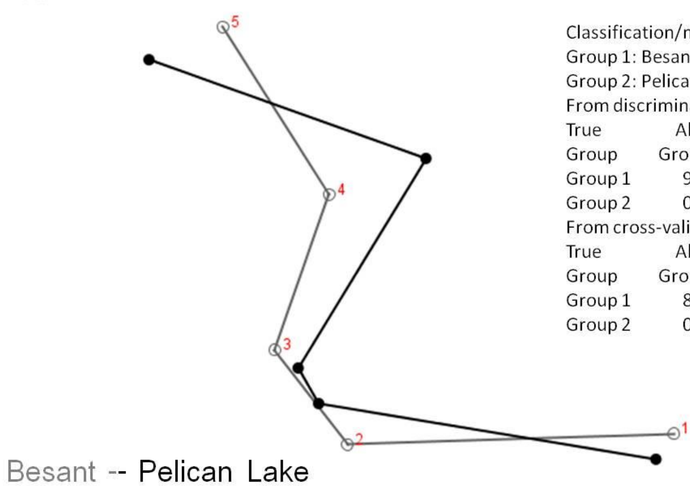
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	8	1	9
Group 2	1	4	5

Figure B.5 DFA Results between Besant (light) and Outlook (dark).

Comparison: Besant -- Pelican Lake

Difference between means:
Procrustes distance: 0.30452634
Mahalanobis distance: 6.1292
T-square: 185.9598, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001



Classification/misclassification tables
Group 1: Besant
Group 2: Pelican Lake
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	9	0	9
Group 2	0	11	11

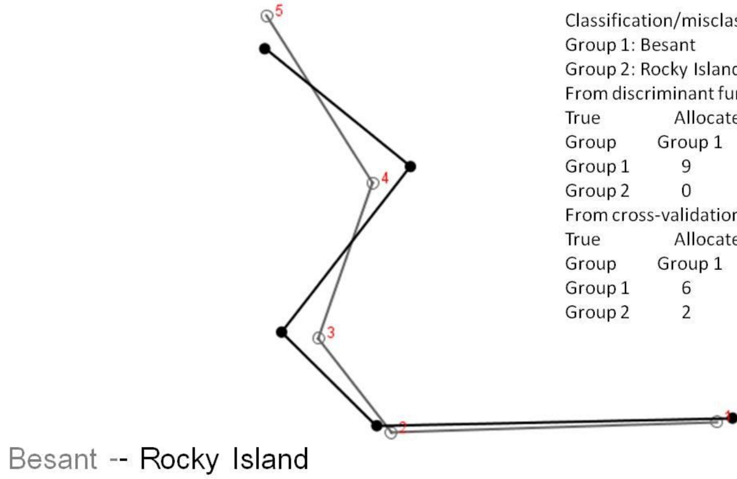
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	8	1	9
Group 2	0	11	11

Figure B.6 DFA Results between Besant (light) and Pelican Lake (dark).

Comparison: Besant -- Rocky Island

Difference between means:
Procrustes distance: 0.13552662
Mahalanobis distance: 5.2442
T-square: 45.0024, P-value (parametric): 0.1319
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0480
T-square: 0.1090



Classification/misclassification tables
Group 1: Besant
Group 2: Rocky Island
From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	9	0	9
Group 2	0	2	2

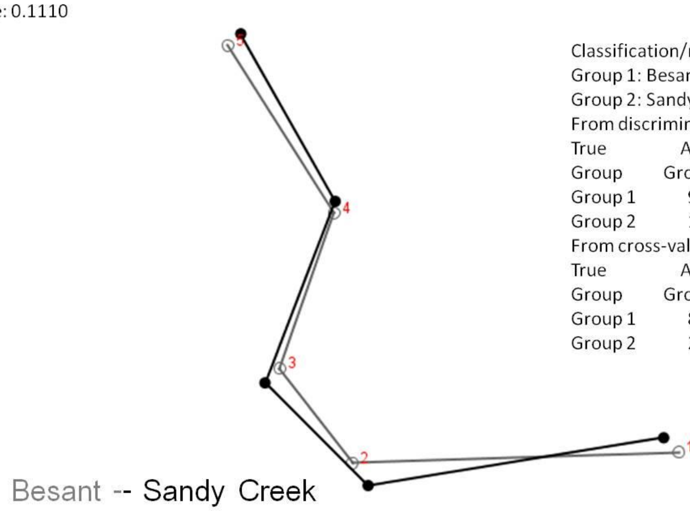
From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	6	3	9
Group 2	2	0	2

Figure B.7 DFA Results between Besant (light) and Rocky Island (dark).

Comparison: Besant -- Sandy Creek

Difference between means:
Procrustes distance: 0.09068829
Mahalanobis distance: 2.9822
T-square: 28.5859, P-value (parametric): 0.1036
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.1840
T-square: 0.1110



Classification/misclassification tables
Group 1: Besant
Group 2: Sandy Creek
From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	9	0	9
Group 2	1	4	5

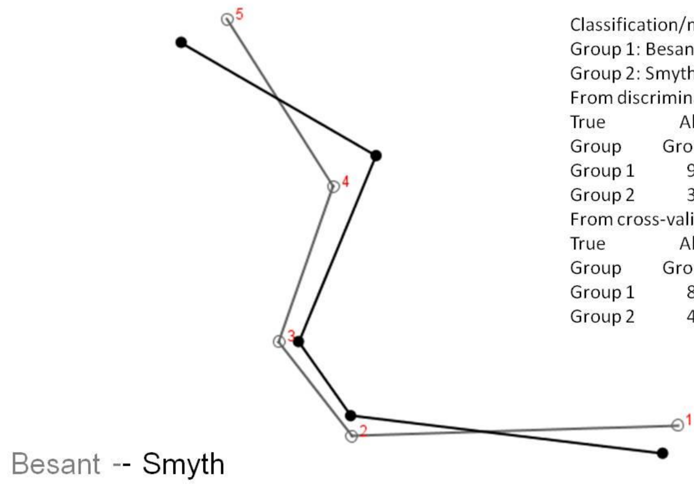
From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	8	1	9
Group 2	2	3	5

Figure B.8 DFA Results between Besant (light) and Sandy Creek (dark).

Comparison: Besant -- Smyth

Difference between means:
Procrustes distance: 0.17042526
Mahalanobis distance: 3.1322
T-square: 71.3892, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001



Classification/misclassification tables
Group 1: Besant
Group 2: Smyth
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	9	0	9
Group 2	3	35	38

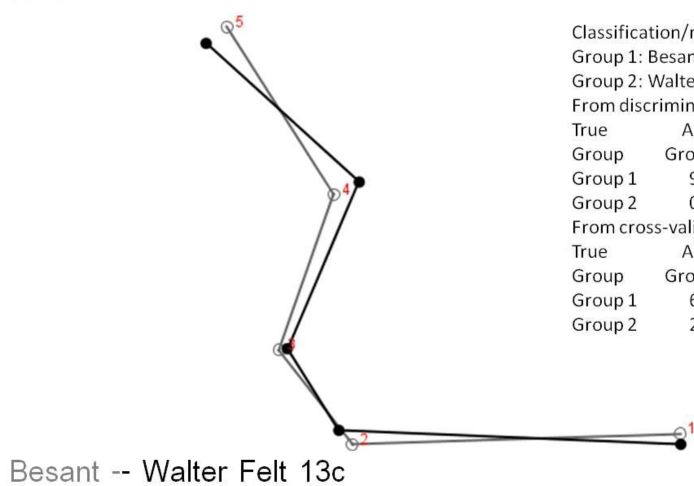
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	8	1	9
Group 2	4	34	38

Figure B.9 DFA Results between Besant (light) and Smyth (dark).

Comparison: Besant -- Walter Felt 13c

Difference between means:
Procrustes distance: 0.09004814
Mahalanobis distance: 3.2693
T-square: 38.4789, P-value (parametric): 0.0389
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.2300
T-square: 0.0420



Classification/misclassification tables
Group 1: Besant
Group 2: Walter Felt 13c
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	9	0	9
Group 2	0	6	6

From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	6	3	9
Group 2	2	4	6

Figure B.10 DFA Results between Besant (light) and Walter Felt 13c (dark).

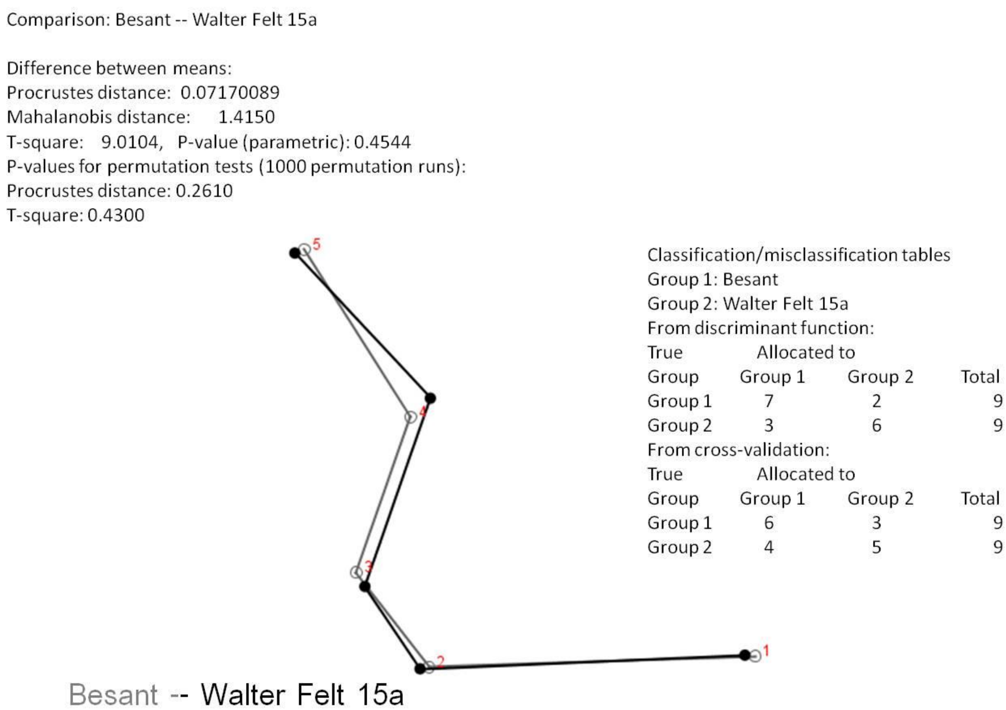


Figure B..11 DFA Results between Besant (light) and Walter Felt 15a (dark).

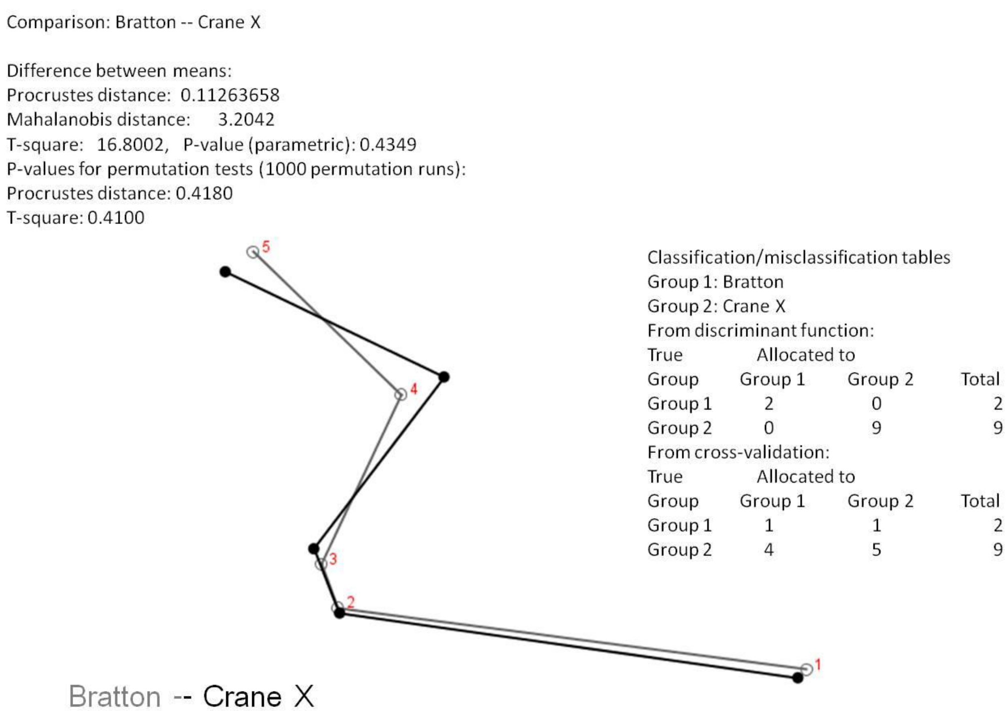


Figure B.12 DFA Results between Bratton (light) and Crane X (dark).

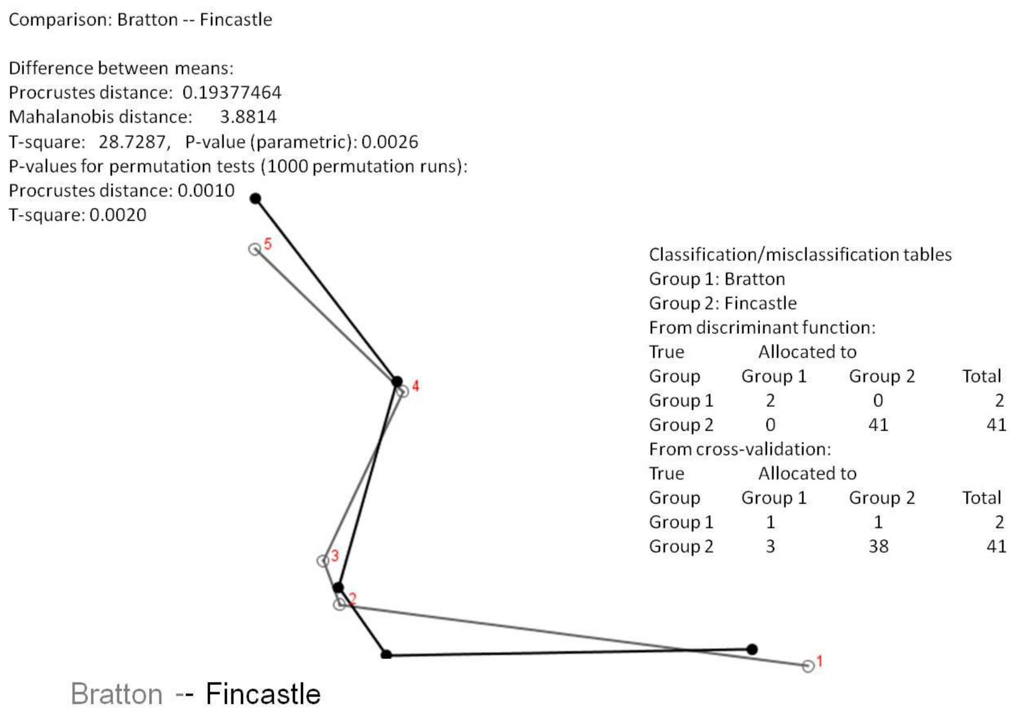


Figure B.13 DFA Results between Bratton (light) and Fincastle (dark).

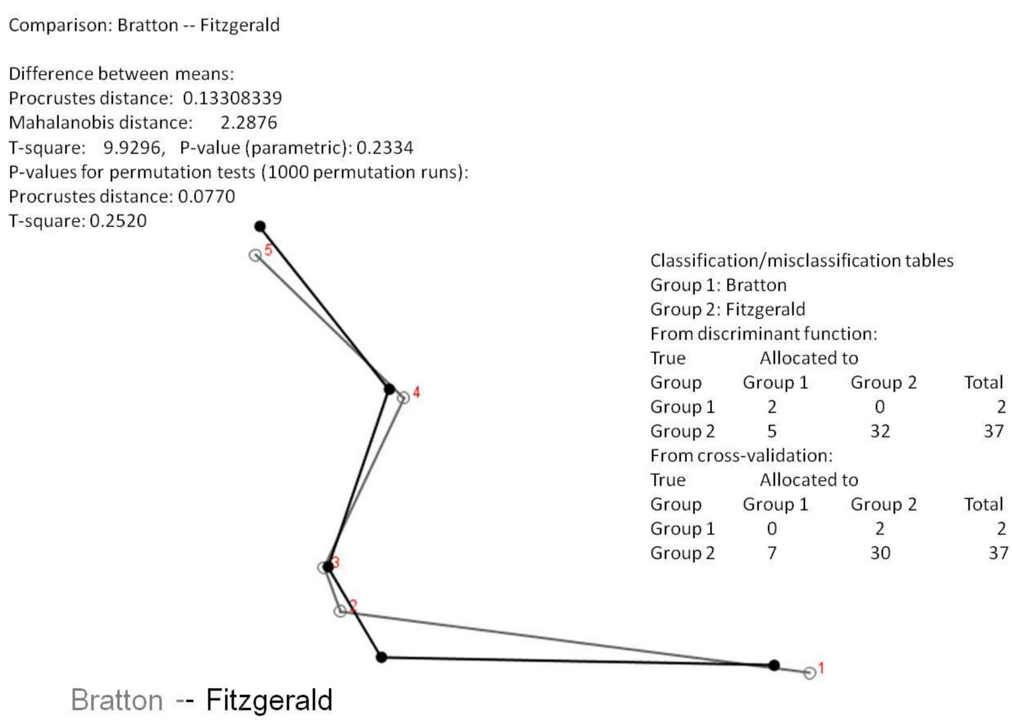


Figure B.14 DFA Results between Bratton (light) and Fitzgerald (dark).

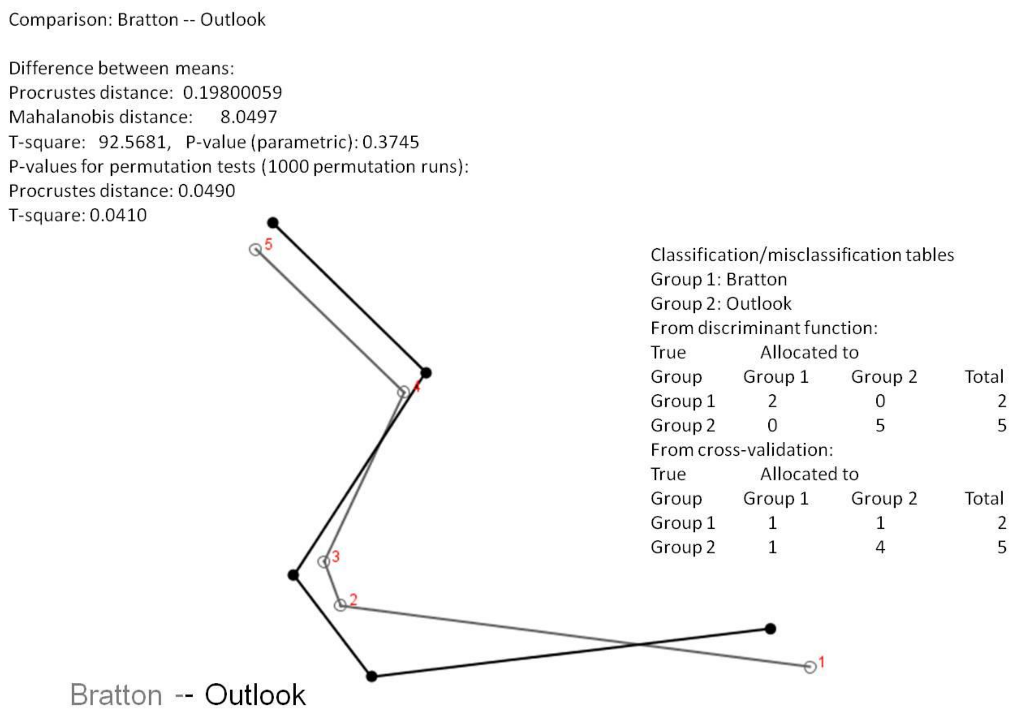


Figure B.15 DFA Results between Bratton (light) and Outlook (dark).

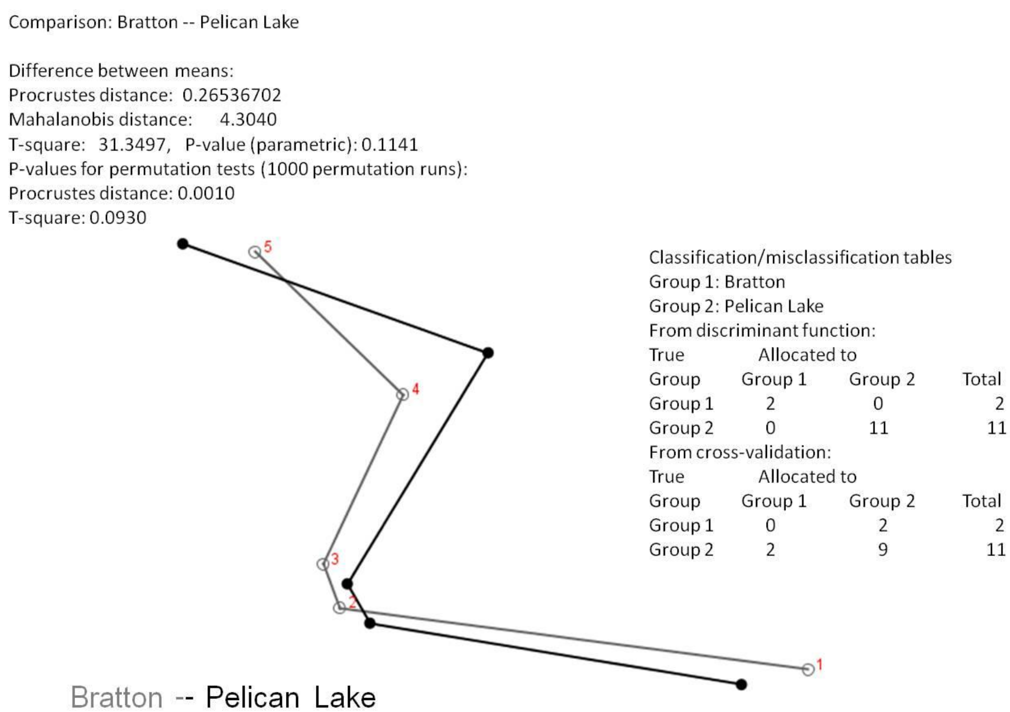
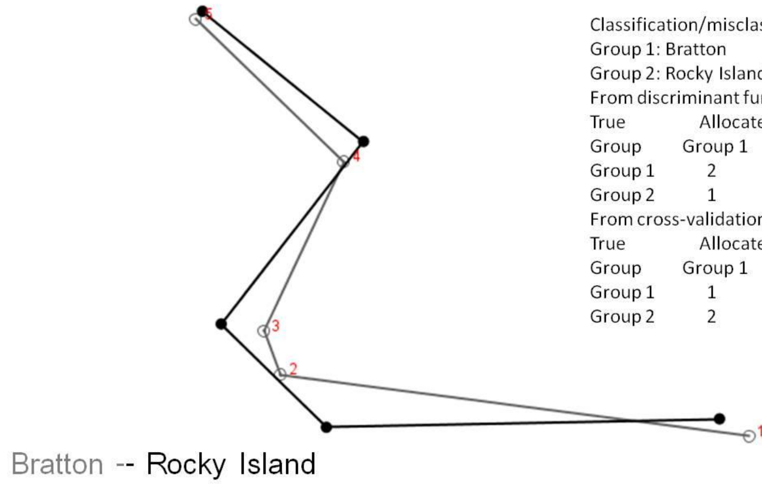


Figure B.16 DFA Results between Bratton (light) and Pelican Lake (dark).

Comparison: Bratton -- Rocky Island

Difference between means:
Procrustes distance: 0.17005034
Mahalanobis distance: 0.5967
T-square: 0.3561, P-value (parametric): 0.9213
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.3270
T-square: 0.3270



Classification/misclassification tables
Group 1: Bratton
Group 2: Rocky Island
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	2	0	2
Group 2	1	1	2

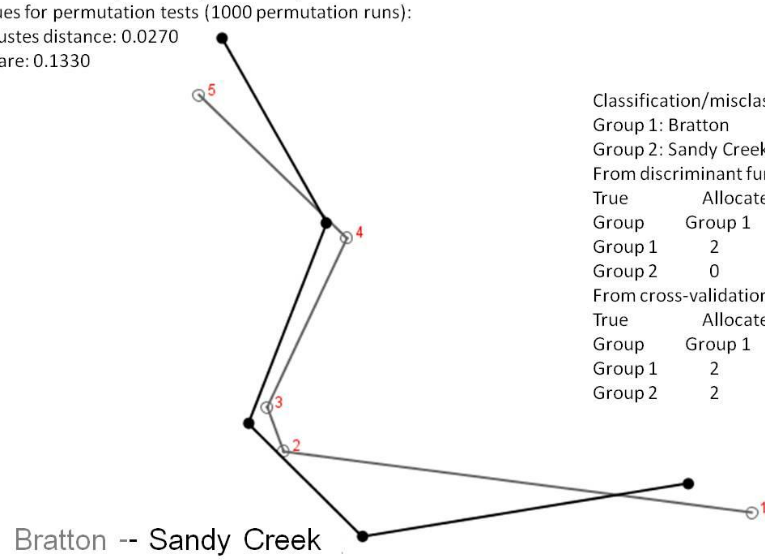
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	1	1	2
Group 2	2	0	2

Figure B.17 DFA Results between Bratton (light) and Rocky Island (dark).

Comparison: Bratton -- Sandy Creek

Difference between means:
Procrustes distance: 0.27502101
Mahalanobis distance: 8.8530
T-square: 111.9650, P-value (parametric): 0.3435
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0270
T-square: 0.1330



Classification/misclassification tables
Group 1: Bratton
Group 2: Sandy Creek
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	2	0	2
Group 2	0	5	5

From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	2	0	2
Group 2	2	3	5

Figure B.18 DFA Results between Bratton (light) and Sandy Creek (dark).

Comparison: Bratton -- Smyth

Difference between means:
Procrustes distance: 0.21337467
Mahalanobis distance: 3.8868
T-square: 28.7042, P-value (parametric): 0.0032
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: 0.0100

Classification/misclassification tables
Group 1: Bratton
Group 2: Smyth
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	2	0	2
Group 2	1	37	38

From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	1	1	2
Group 2	1	37	38

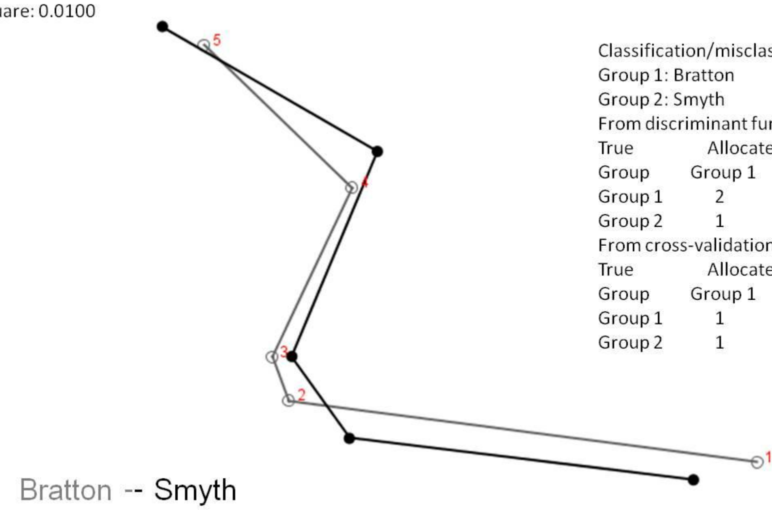


Figure B.19 DFA Results between Bratton (light) and Smyth (dark).

Comparison: Bratton -- Walter Felt 13c

Difference between means:
Procrustes distance: 0.15686419
Mahalanobis distance: 36.0838
T-square: 1953.0612, P-value (parametric): 0.1036
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.3060
T-square: 0.0550

Classification/misclassification tables
Group 1: Bratton
Group 2: Walter Felt 13c
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	2	0	2
Group 2	0	6	6

From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	1	1	2
Group 2	3	3	6

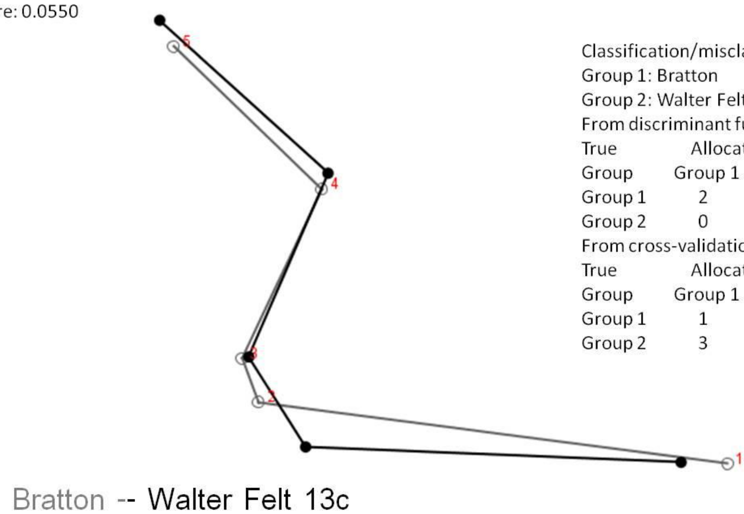


Figure B.20 DFA Results between Bratton (light) and Walter Felt 13c (dark).

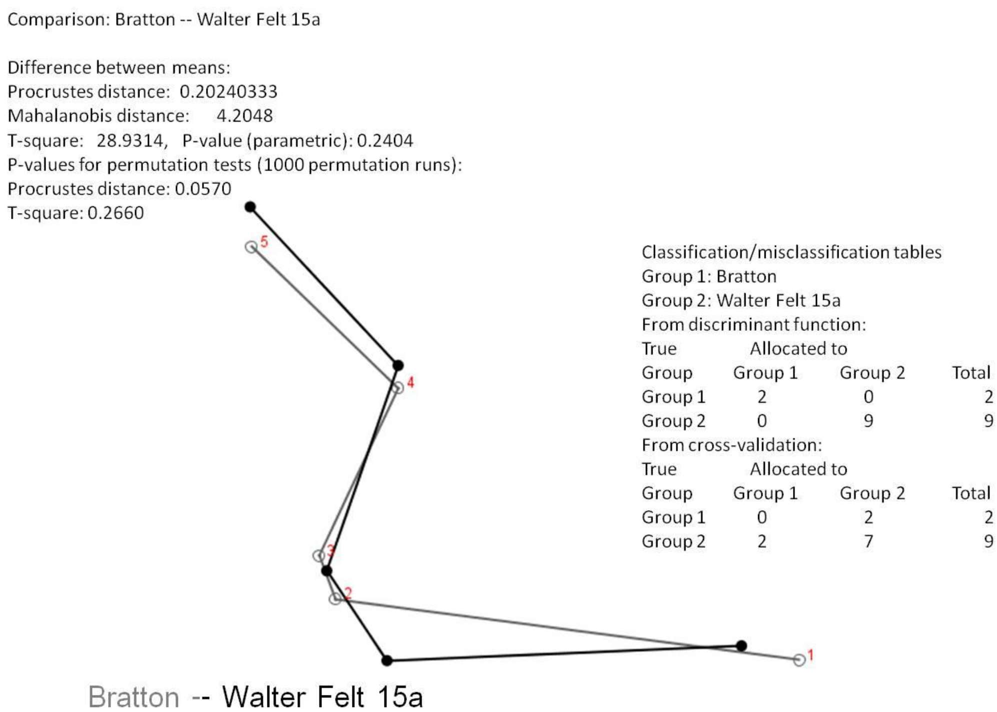


Figure B.21 DFA Results between Bratton (light) and Walter Felt 15a (dark).

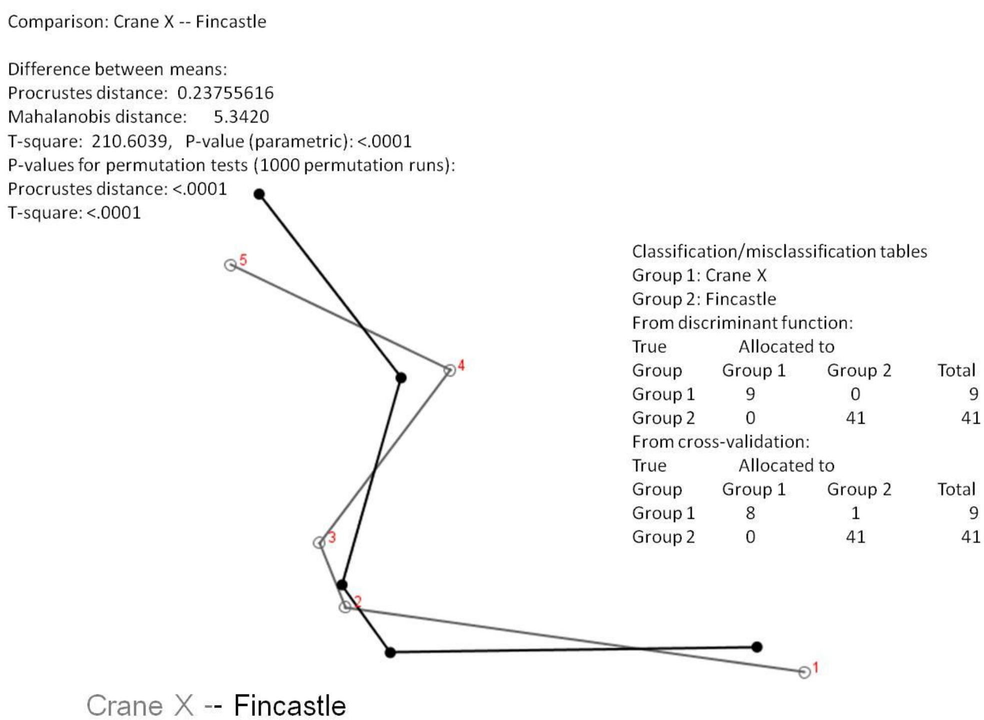


Figure B.22 DFA Results between Crane X (light) and Fincastle (dark).

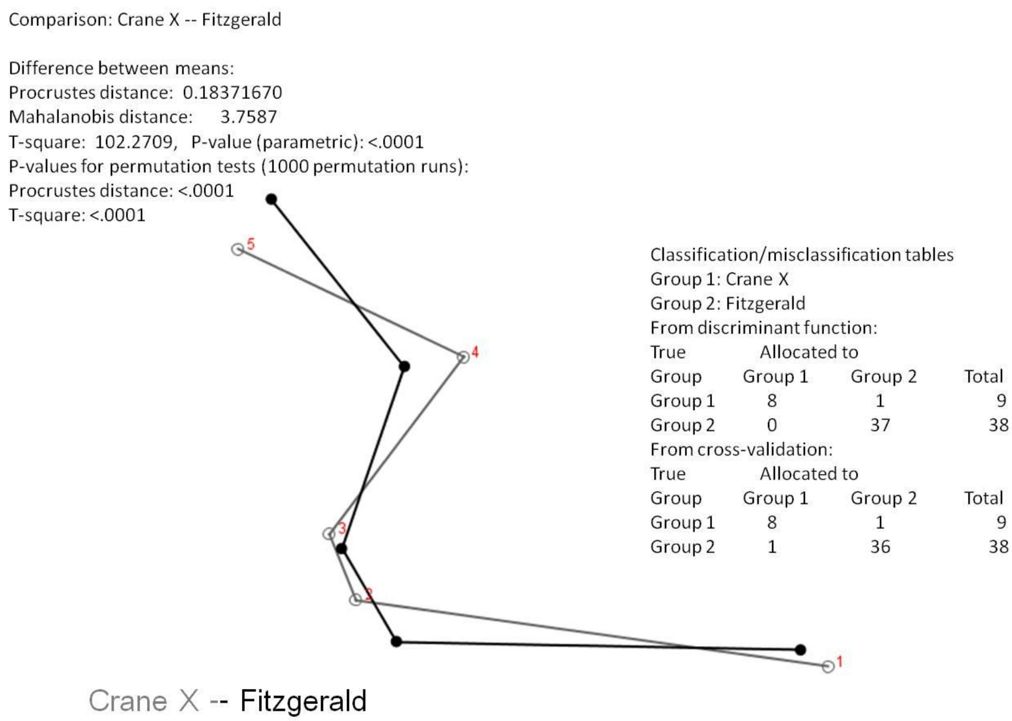


Figure B.23 DFA Results between Crane X (light) and Fitzgerald (dark).

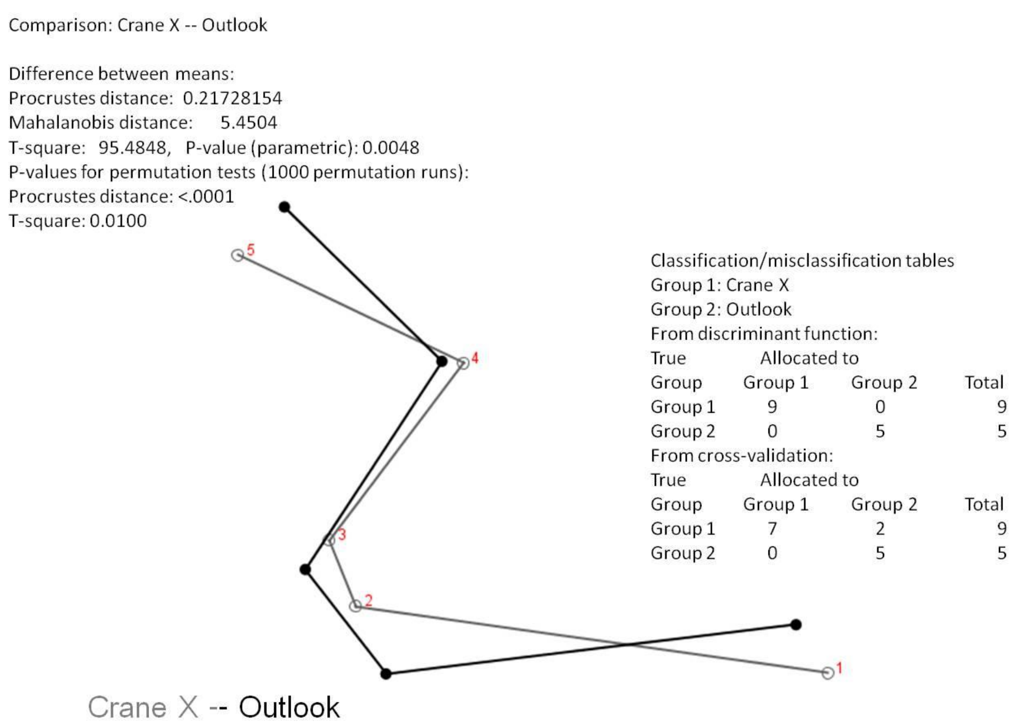


Figure B.24 DFA Results between Crane X (light) and Outlook (dark).

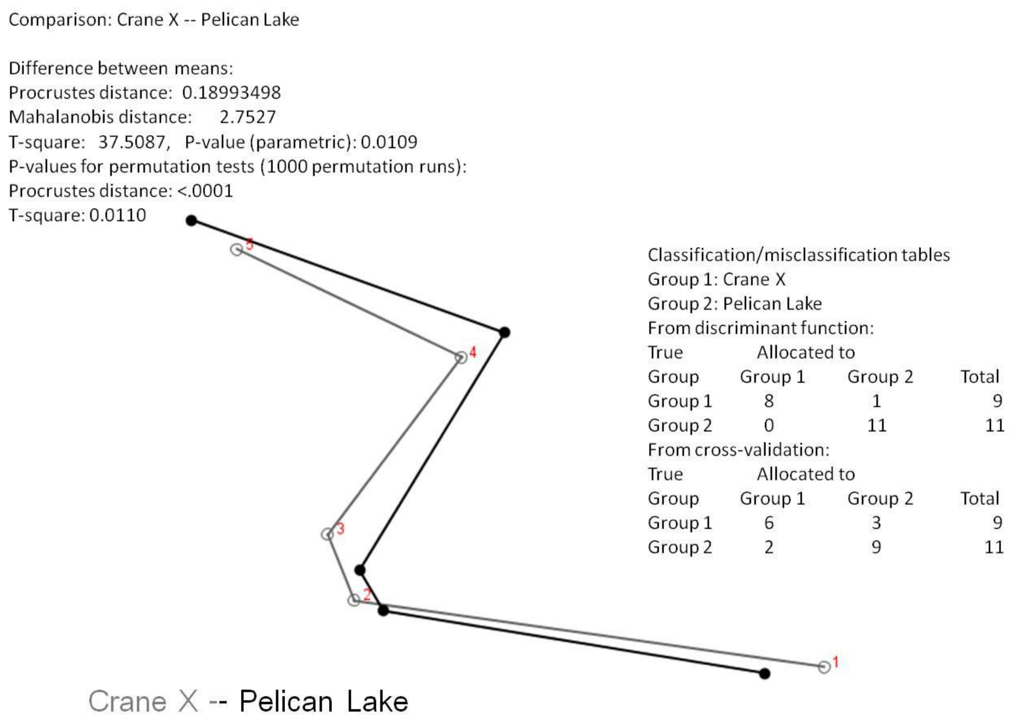


Figure B.25 DFA Results between Crane X (light) and Pelican Lake (dark).

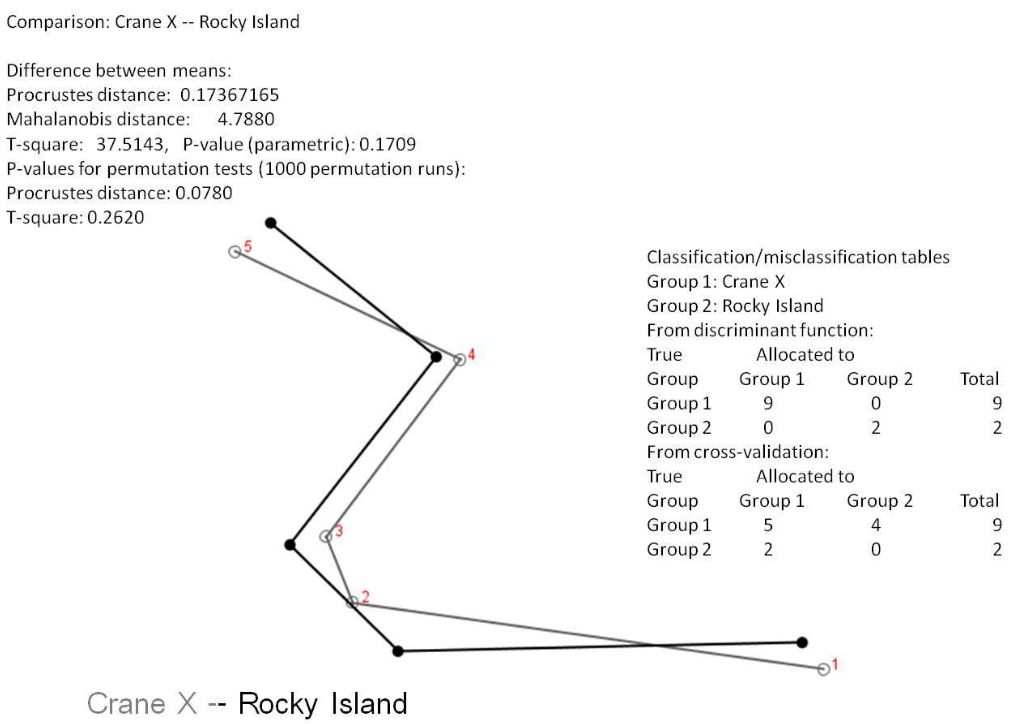
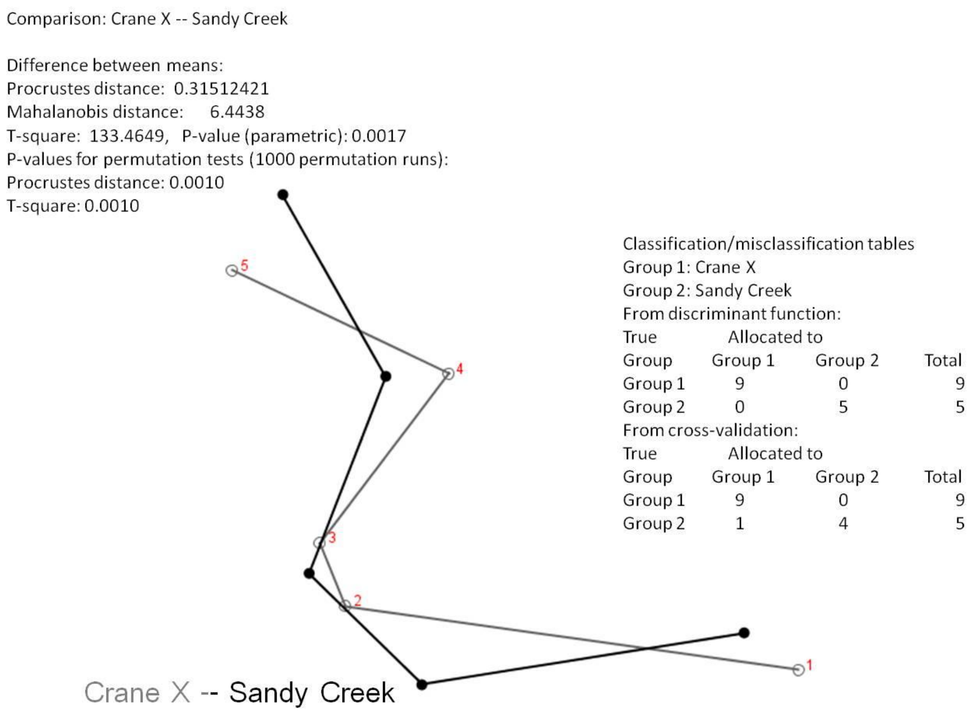


Figure B.26 DFA Results between Crane X (light) and Rocky Island (dark).



Comparison: Crane X -- Sandy Creek

Difference between means:
Procrustes distance: 0.31512421
Mahalanobis distance: 6.4438
T-square: 133.4649, P-value (parametric): 0.0017
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0010
T-square: 0.0010

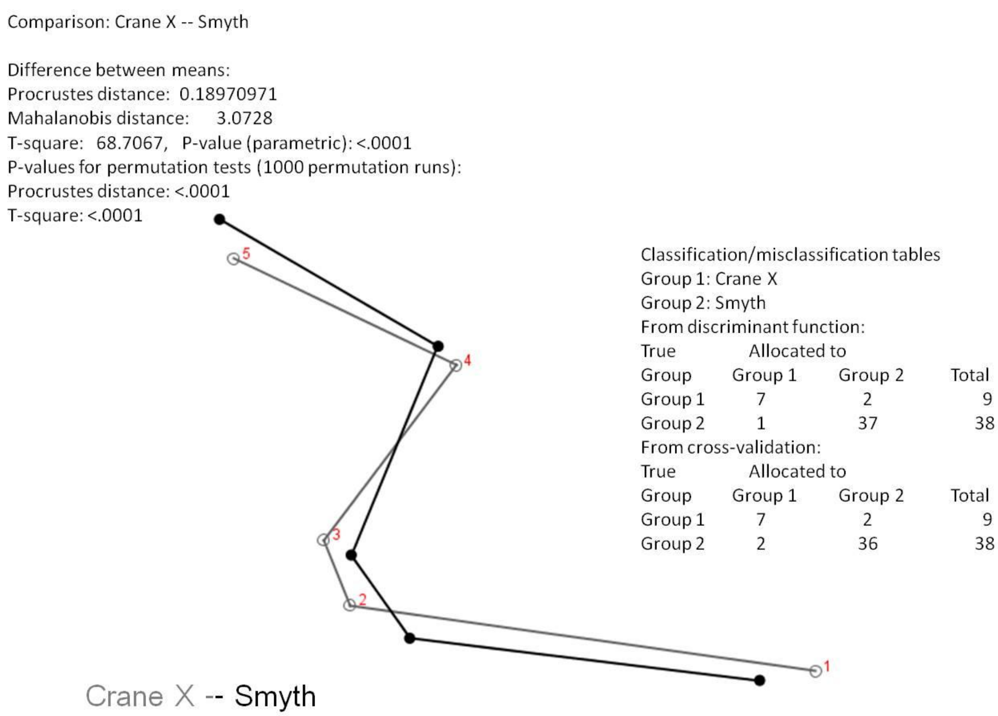
Classification/misclassification tables
Group 1: Crane X
Group 2: Sandy Creek
From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	9	0	9
Group 2	0	5	5

From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	9	0	9
Group 2	1	4	5

Figure B.27 DFA Results between Crane X (light) and Sandy Creek (dark).



Comparison: Crane X -- Smyth

Difference between means:
Procrustes distance: 0.18970971
Mahalanobis distance: 3.0728
T-square: 68.7067, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001

Classification/misclassification tables
Group 1: Crane X
Group 2: Smyth
From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	7	2	9
Group 2	1	37	38

From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	7	2	9
Group 2	2	36	38

Figure B.28 DFA Results between Crane X (light) and Smyth (dark).

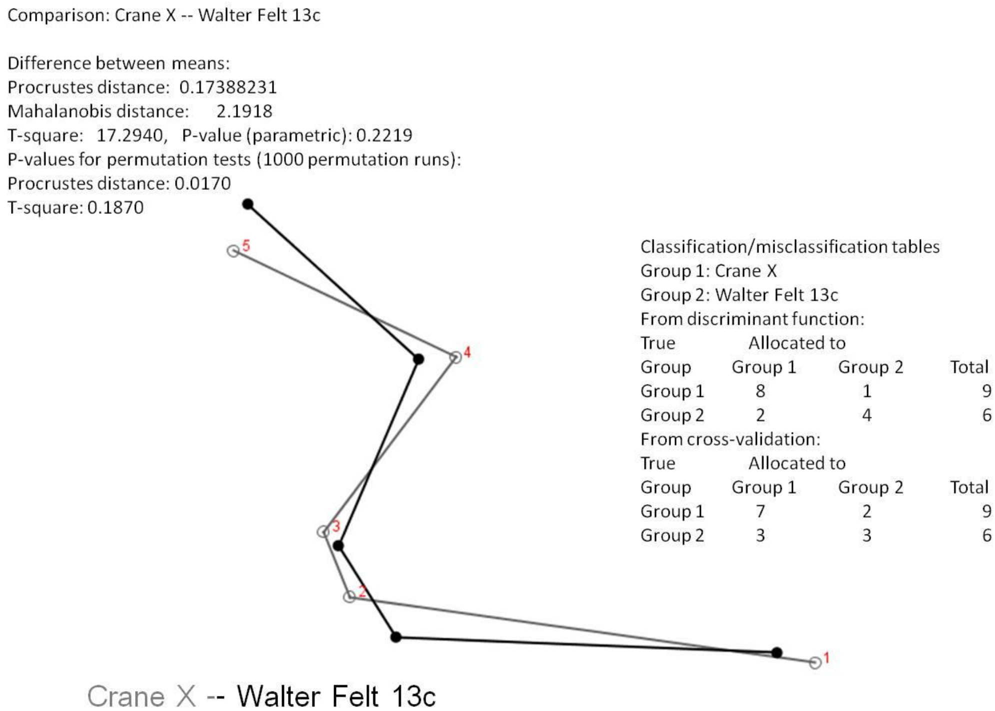


Figure B.29 DFA Results between Crane X (light) and Walter Felt 13c (dark).

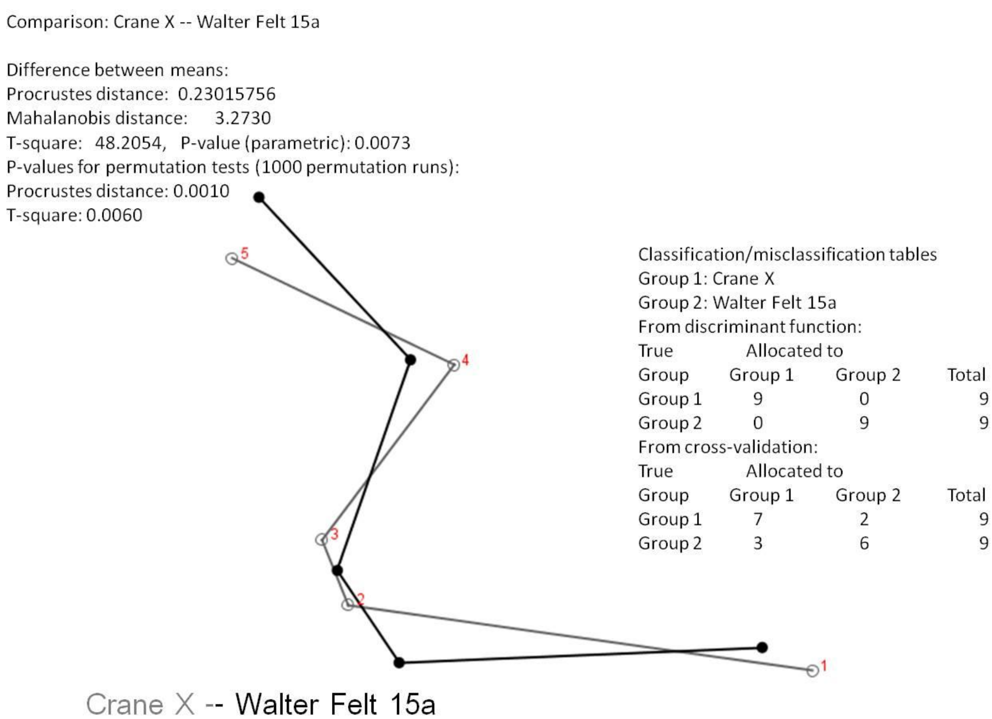
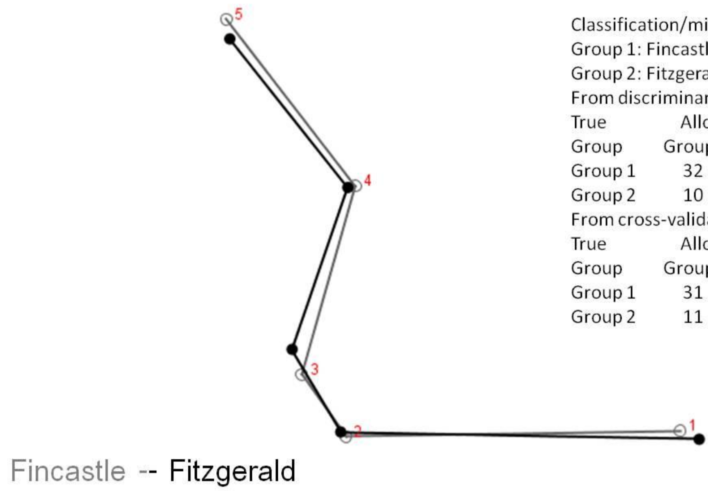


Figure B.30 DFA Results between Crane X (light) and Walter Felt 15a (dark).

Comparison: Fincastle -- Fitzgerald

Difference between means:
Procrustes distance: 0.08368407
Mahalanobis distance: 1.5597
T-square: 47.3096, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001



Classification/misclassification tables
Group 1: Fincastle
Group 2: Fitzgerald
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	32	9	41
Group 2	10	27	37

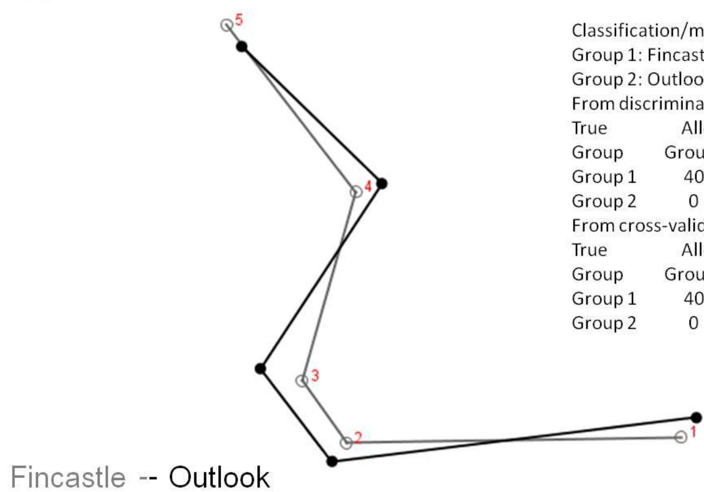
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	31	10	41
Group 2	11	26	37

Figure B.31 DFA Results between Fincastle (light) and Fitzgerald (dark).

Comparison: Fincastle -- Outlook

Difference between means:
Procrustes distance: 0.13099843
Mahalanobis distance: 4.0996
T-square: 74.8980, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0010
T-square: <.0001



Classification/misclassification tables
Group 1: Fincastle
Group 2: Outlook
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	40	1	41
Group 2	0	5	5

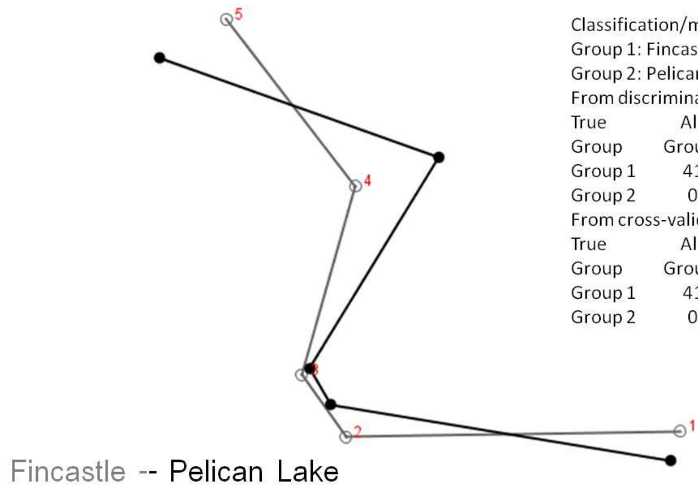
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	40	1	41
Group 2	0	5	5

Figure B.32 DFA Results between Fincastle (light) and Outlook (dark).

Comparison: Fincastle -- Pelican Lake

Difference between means:
Procrustes distance: 0.26377663
Mahalanobis distance: 5.3491
T-square: 248.1656, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001



Classification/misclassification tables
Group 1: Fincastle
Group 2: Pelican Lake
From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	41	0	41
Group 2	0	11	11

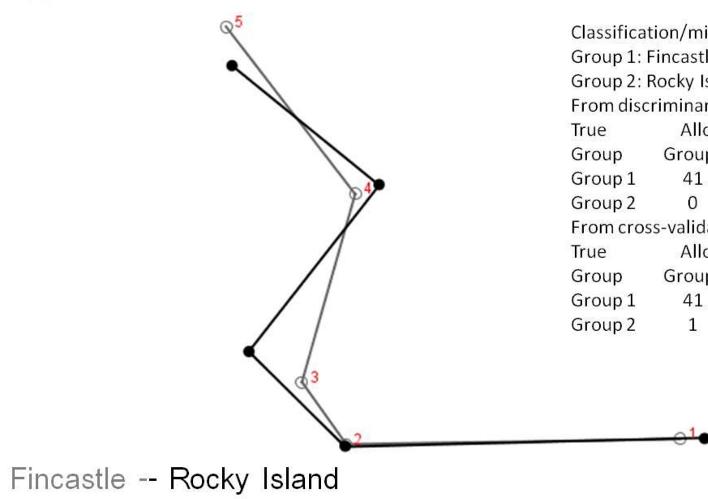
From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	41	0	41
Group 2	0	11	11

Figure B.33 DFA Results between Fincastle (light) and Pelican Lake (dark).

Comparison: Fincastle -- Rocky Island

Difference between means:
Procrustes distance: 0.15818417
Mahalanobis distance: 5.5005
T-square: 57.6955, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0110
T-square: <.0001



Classification/misclassification tables
Group 1: Fincastle
Group 2: Rocky Island
From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	41	0	41
Group 2	0	2	2

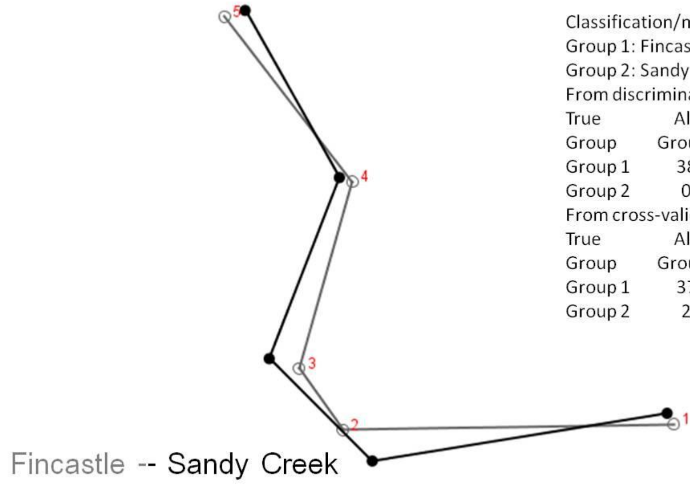
From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	41	0	41
Group 2	1	1	2

Figure B.34 DFA Results between Fincastle (light) and Rocky Island (dark).

Comparison: Fincastle -- Sandy Creek

Difference between means:
Procrustes distance: 0.12176952
Mahalanobis distance: 2.8430
T-square: 36.0202, P-value (parametric): 0.0004
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0030
T-square: 0.0010



Classification/misclassification tables
Group 1: Fincastle
Group 2: Sandy Creek

From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	38	3	41
Group 2	0	5	5

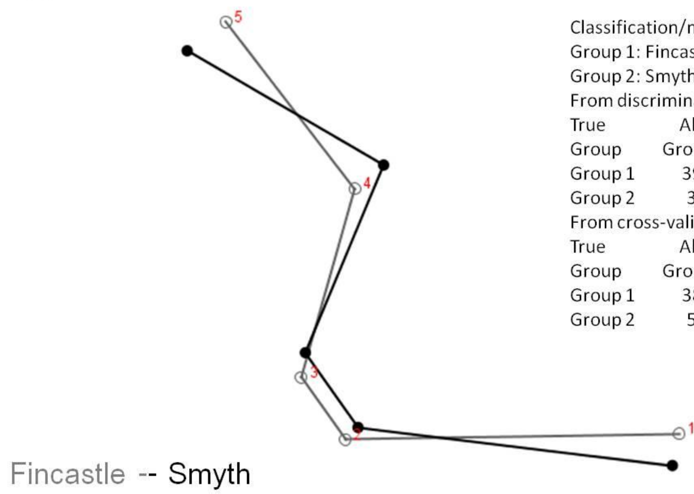
From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	37	4	41
Group 2	2	3	5

Figure B.35 DFA Results between Fincastle (light) and Sandy Creek (dark).

Comparison: Fincastle -- Smyth

Difference between means:
Procrustes distance: 0.14918787
Mahalanobis distance: 2.8437
T-square: 159.4823, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001



Classification/misclassification tables
Group 1: Fincastle
Group 2: Smyth

From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	39	2	41
Group 2	3	35	38

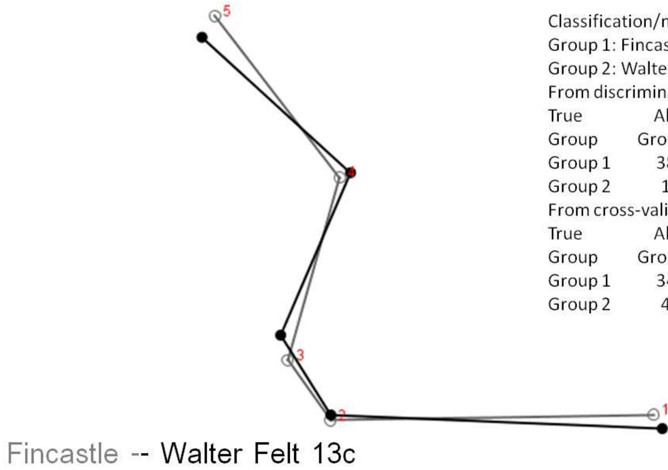
From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	38	3	41
Group 2	5	33	38

Figure B.36 DFA Results between Fincastle (light) and Smyth (dark).

Comparison: Fincastle -- Walter Felt 13c

Difference between means:
Procrustes distance: 0.08401664
Mahalanobis distance: 2.2292
T-square: 26.0094, P-value (parametric): 0.0040
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0790
T-square: 0.0070



Classification/misclassification tables
Group 1: Fincastle
Group 2: Walter Felt 13c

From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	38	3	41
Group 2	1	5	6

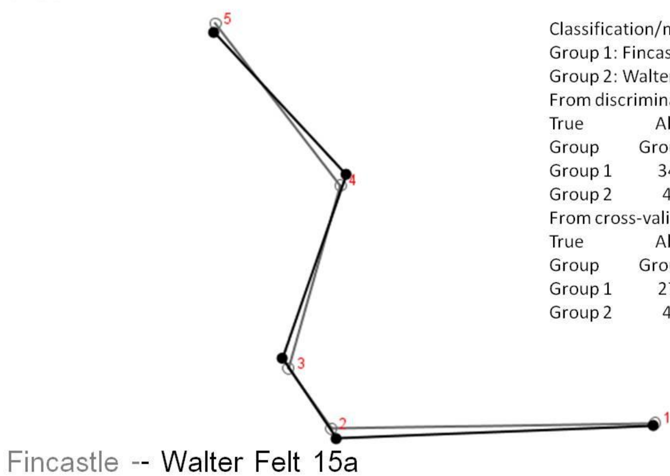
From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	34	7	41
Group 2	4	2	6

Figure B.37 DFA Results between Fincastle (light) and Walter Felt 13c (dark).

Comparison: Fincastle -- Walter Felt 15a

Difference between means:
Procrustes distance: 0.04610271
Mahalanobis distance: 1.2045
T-square: 10.7077, P-value (parametric): 0.1708
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.4240
T-square: 0.1630



Classification/misclassification tables
Group 1: Fincastle
Group 2: Walter Felt 15a

From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	34	7	41
Group 2	4	5	9

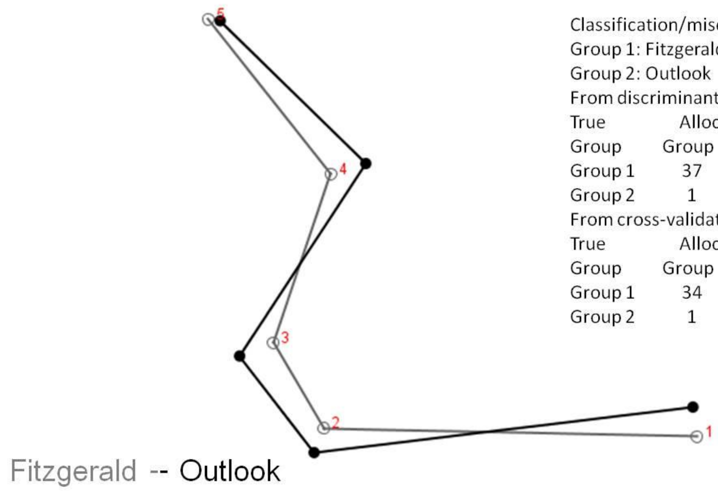
From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	27	14	41
Group 2	4	5	9

Figure B.38 DFA Results between Fincastle (light) and Walter Felt 15a (dark).

Comparison: Fitzgerald -- Outlook

Difference between means:
Procrustes distance: 0.12410370
Mahalanobis distance: 2.9526
T-square: 38.3994, P-value (parametric): 0.0004
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0060
T-square: 0.0010



Classification/misclassification tables
Group 1: Fitzgerald
Group 2: Outlook
From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	37	0	37
Group 2	1	4	5

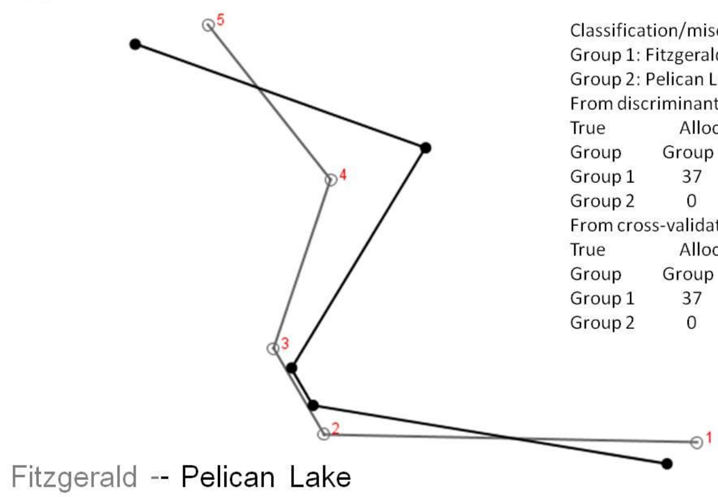
From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	34	3	37
Group 2	1	4	5

Figure B.39 DFA Results between Fitzgerald (light) and Outlook (dark).

Comparison: Fitzgerald -- Pelican Lake

Difference between means:
Procrustes distance: 0.26461259
Mahalanobis distance: 5.9023
T-square: 295.3905, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001



Classification/misclassification tables
Group 1: Fitzgerald
Group 2: Pelican Lake
From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	37	0	37
Group 2	0	11	11

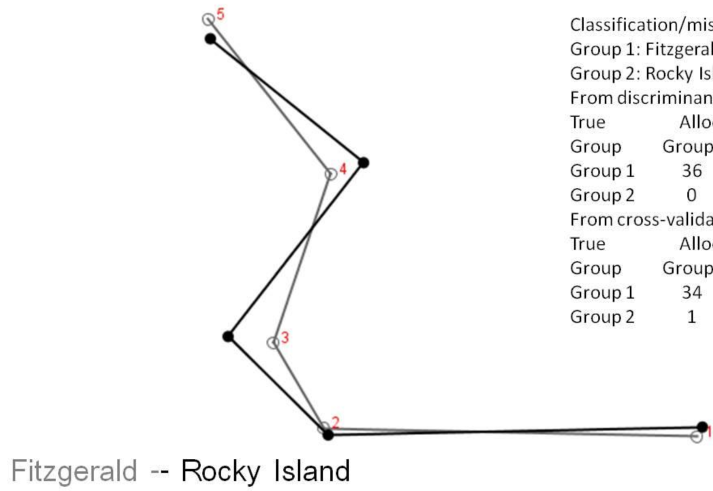
From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	37	0	37
Group 2	0	11	11

Figure B.40 DFA Results between Fitzgerald (light) and Pelican Lake (dark).

Comparison: Fitzgerald -- Rocky Island

Difference between means:
Procrustes distance: 0.11599158
Mahalanobis distance: 3.7808
T-square: 27.1222, P-value (parametric): 0.0048
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.1520
T-square: 0.0090



Classification/misclassification tables
Group 1: Fitzgerald
Group 2: Rocky Island
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	36	1	37
Group 2	0	2	2

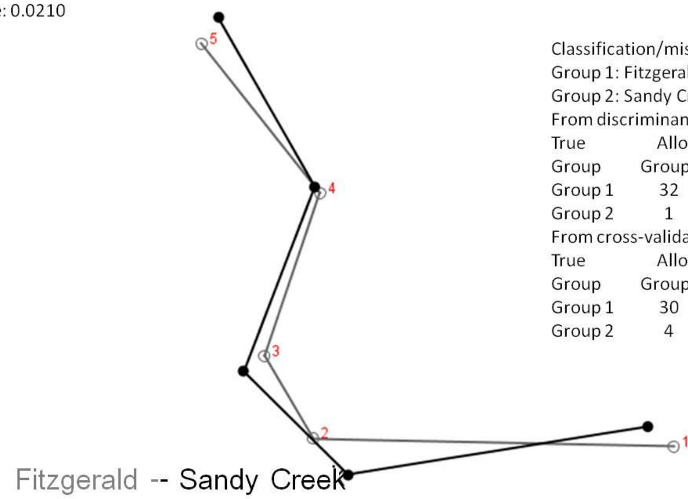
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	34	3	37
Group 2	1	1	2

Figure B.41 DFA Results between Fitzgerald (light) and Rocky Island (dark).

Comparison: Fitzgerald -- Sandy Creek

Difference between means:
Procrustes distance: 0.15149101
Mahalanobis distance: 2.2382
T-square: 22.0650, P-value (parametric): 0.0127
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0010
T-square: 0.0210



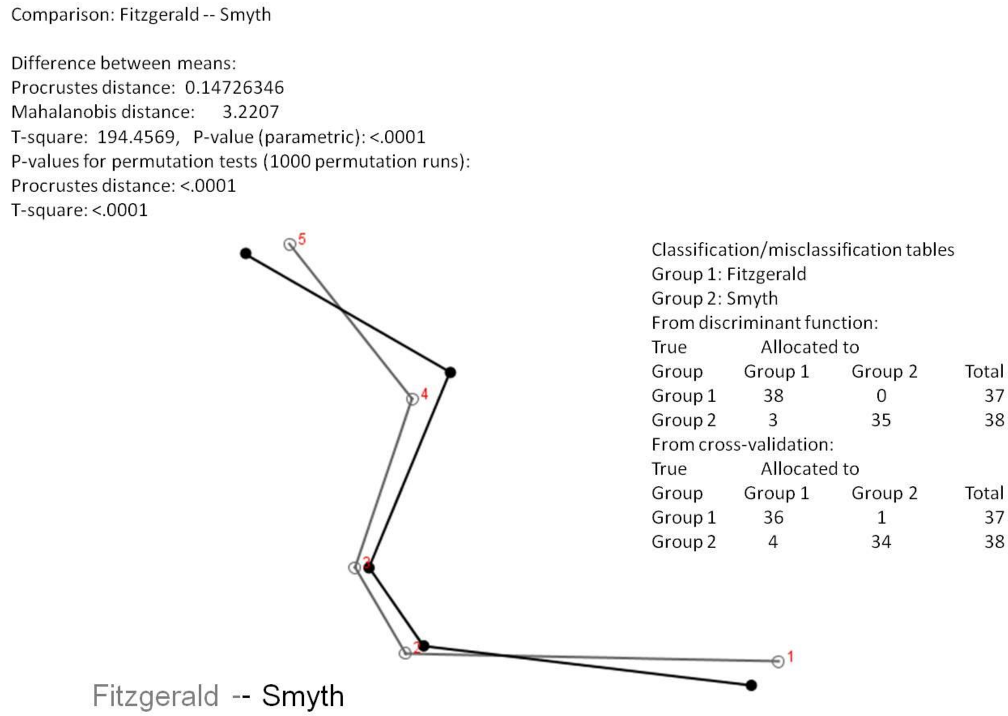
Classification/misclassification tables
Group 1: Fitzgerald
Group 2: Sandy Creek
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	32	5	37
Group 2	1	4	5

From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	30	7	37
Group 2	4	1	5

Figure B.42 DFA Results between Fitzgerald (light) and Sandy Creek (dark).



Comparison: Fitzgerald -- Smyth

Difference between means:
Procrustes distance: 0.14726346
Mahalanobis distance: 3.2207
T-square: 194.4569, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001

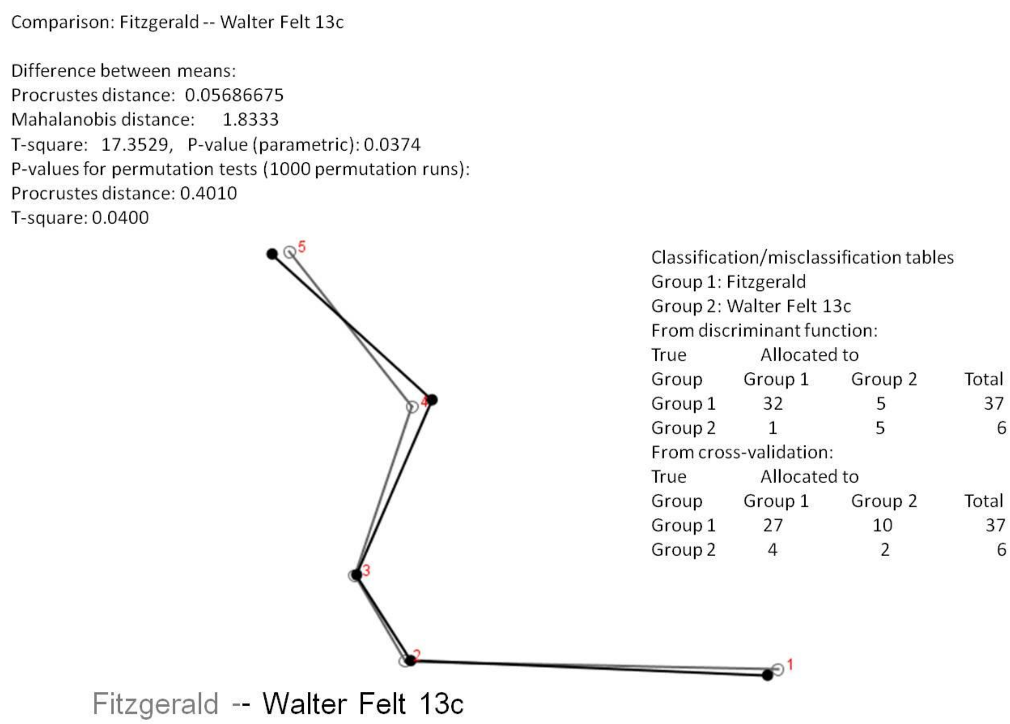
Classification/misclassification tables
Group 1: Fitzgerald
Group 2: Smyth
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	38	0	37
Group 2	3	35	38

From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	36	1	37
Group 2	4	34	38

Figure B.43 DFA Results between Fitzgerald (light) and Smyth (dark).



Comparison: Fitzgerald -- Walter Felt 13c

Difference between means:
Procrustes distance: 0.05686675
Mahalanobis distance: 1.8333
T-square: 17.3529, P-value (parametric): 0.0374
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.4010
T-square: 0.0400

Classification/misclassification tables
Group 1: Fitzgerald
Group 2: Walter Felt 13c
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	32	5	37
Group 2	1	5	6

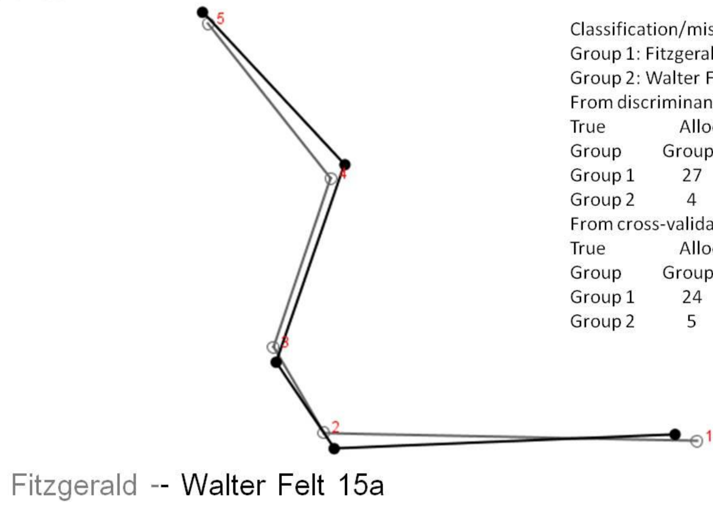
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	27	10	37
Group 2	4	2	6

Figure B.44 DFA Results between Fitzgerald (light) and Walter Felt 13c (dark).

Comparison: Fitzgerald -- Walter Felt 15a

Difference between means:
Procrustes distance: 0.08127666
Mahalanobis distance: 1.3239
T-square: 12.6875, P-value (parametric): 0.1099
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0440
T-square: 0.1060



Classification/misclassification tables
Group 1: Fitzgerald
Group 2: Walter Felt 15a
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	27	10	37
Group 2	4	5	9

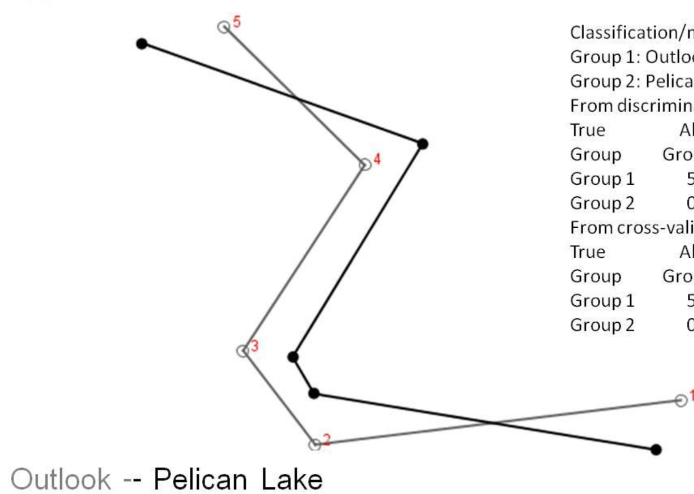
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	24	13	37
Group 2	5	4	9

Figure B.45 DFA Results between Fitzgerald (light) and Walter Felt 15a (dark).

Comparison: Outlook -- Pelican Lake

Difference between means:
Procrustes distance: 0.27751988
Mahalanobis distance: 6.0977
T-square: 127.8129, P-value (parametric): 0.0005
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001



Classification/misclassification tables
Group 1: Outlook
Group 2: Pelican Lake
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	5	0	5
Group 2	0	11	11

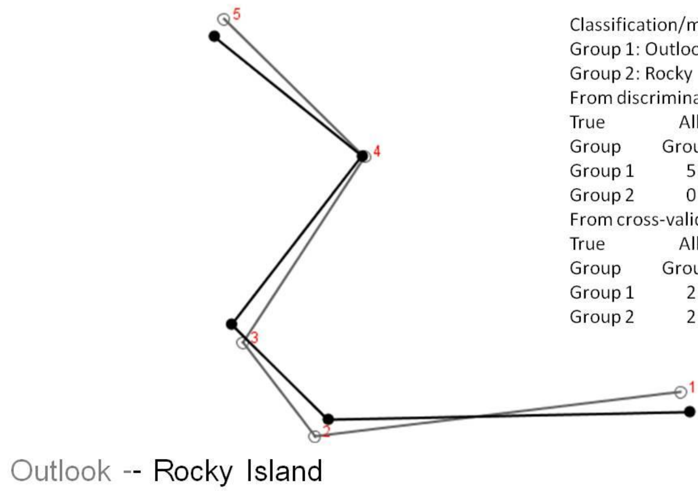
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	5	0	5
Group 2	0	11	11

Figure B.46 DFA Results between Outlook (light) and Pelican Lake (dark).

Comparison: Outlook -- Rocky Island

Difference between means:
Procrustes distance: 0.08359058
Mahalanobis distance: 16.6999
T-square: 398.4110, P-value (parametric): 0.1878
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.5280
T-square: 0.1570



Classification/misclassification tables
Group 1: Outlook
Group 2: Rocky Island
From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	5	0	5
Group 2	0	2	2

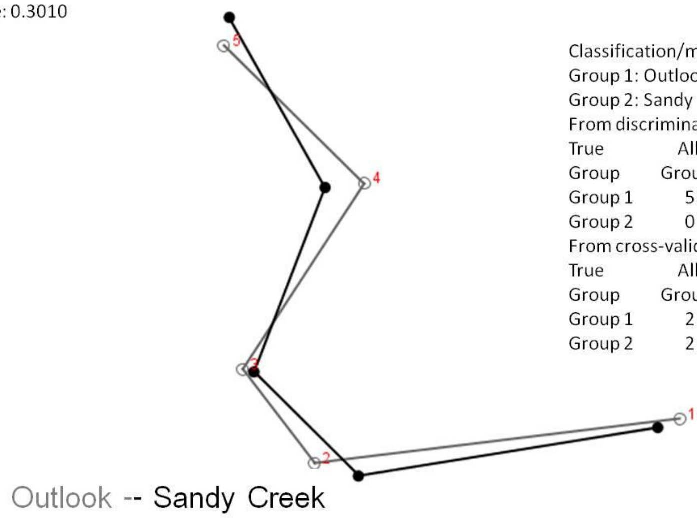
From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	2	3	5
Group 2	2	0	2

Figure B.47 DFA Results between Outlook (light) and Rocky Island (dark).

Comparison: Outlook -- Sandy Creek

Difference between means:
Procrustes distance: 0.13954924
Mahalanobis distance: 3.4389
T-square: 29.5654, P-value (parametric): 0.3284
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0760
T-square: 0.3010



Classification/misclassification tables
Group 1: Outlook
Group 2: Sandy Creek
From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	5	0	5
Group 2	0	5	5

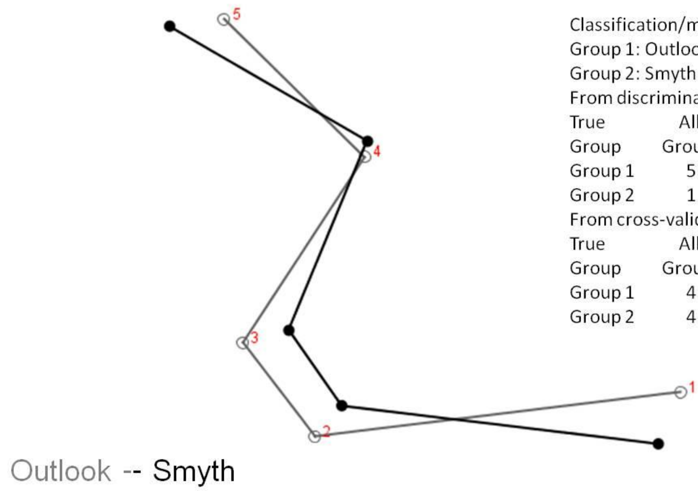
From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	2	3	5
Group 2	2	3	5

Figure B.48 DFA Results between Outlook (light) and Sandy Creek (dark).

Comparison: Outlook -- Smyth

Difference between means:
Procrustes distance: 0.20073561
Mahalanobis distance: 3.6100
T-square: 57.5831, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001



Classification/misclassification tables
Group 1: Outlook
Group 2: Smyth
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	5	0	5
Group 2	1	37	38

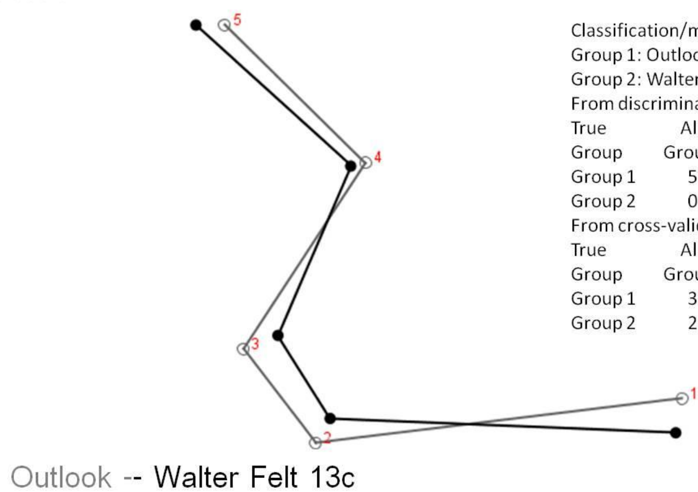
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	4	1	5
Group 2	4	34	38

Figure B.49 DFA Results between Outlook (light) and Smyth (dark).

Comparison: Outlook -- Walter Felt 13c

Difference between means:
Procrustes distance: 0.13068378
Mahalanobis distance: 5.1314
T-square: 71.8138, P-value (parametric): 0.0638
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.1450
T-square: 0.0570



Classification/misclassification tables
Group 1: Outlook
Group 2: Walter Felt 13c
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	5	0	5
Group 2	0	6	6

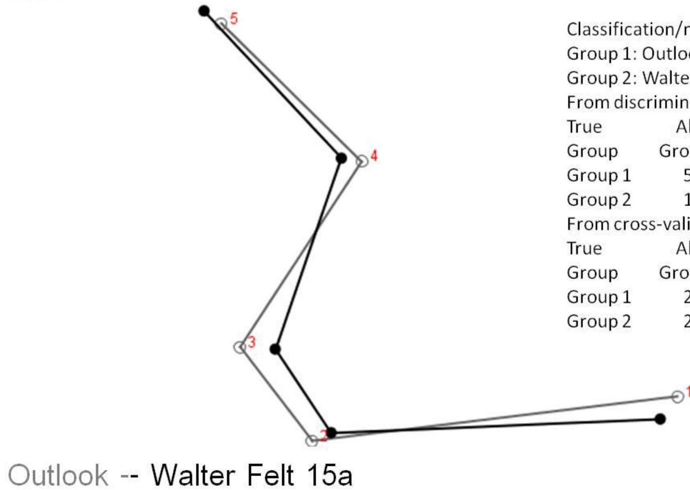
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	3	2	5
Group 2	2	4	6

Figure B.50 DFA Results between Outlook (light) and Walter Felt 13c (dark).

Comparison: Outlook -- Walter Felt 15a

Difference between means:
Procrustes distance: 0.11356788
Mahalanobis distance: 3.1718
T-square: 32.3361, P-value (parametric): 0.0799
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.1370
T-square: 0.0950



Classification/misclassification tables
Group 1: Outlook
Group 2: Walter Felt 15a
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	5	0	5
Group 2	1	8	9

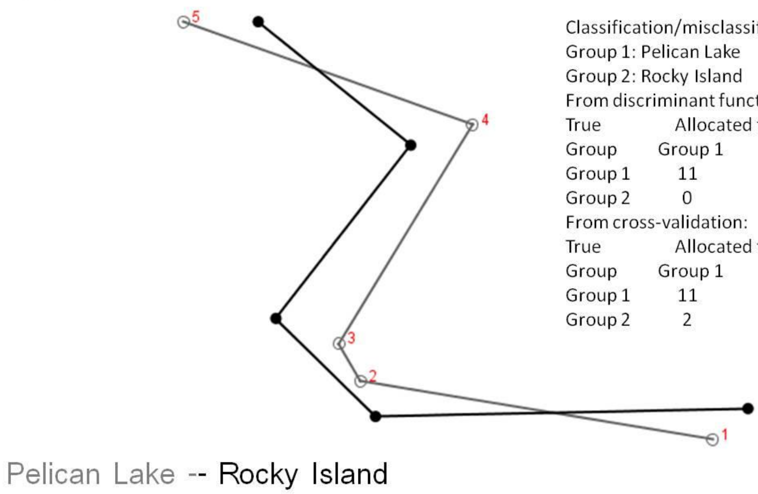
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	2	3	5
Group 2	2	7	9

Figure B.51 DFA Results between Outlook (light) and Walter Felt 15a (dark).

Comparison: Pelican Lake -- Rocky Island

Difference between means:
Procrustes distance: 0.26054811
Mahalanobis distance: 7.0081
T-square: 83.1159, P-value (parametric): 0.0133
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0080
T-square: 0.0420



Classification/misclassification tables
Group 1: Pelican Lake
Group 2: Rocky Island
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	11	0	11
Group 2	0	2	2

From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	11	0	11
Group 2	2	0	2

Figure B.52 DFA Results between Pelican Lake (light) and Rocky Island (dark).

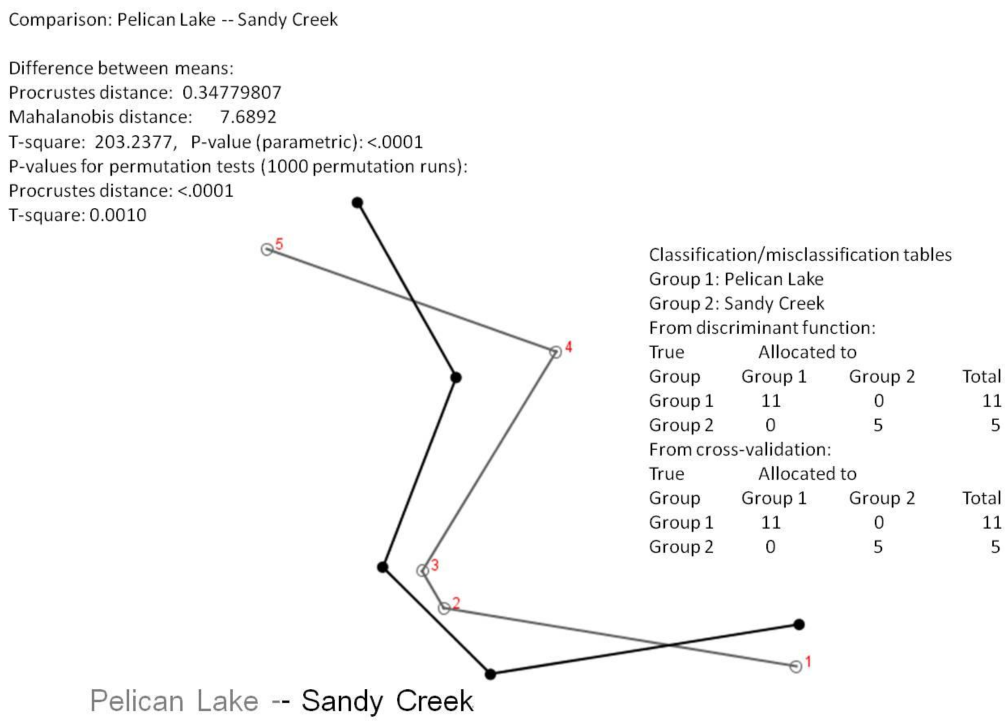


Figure B.53 DFA Results between Pelican Lake (light) and Sandy Creek (dark).

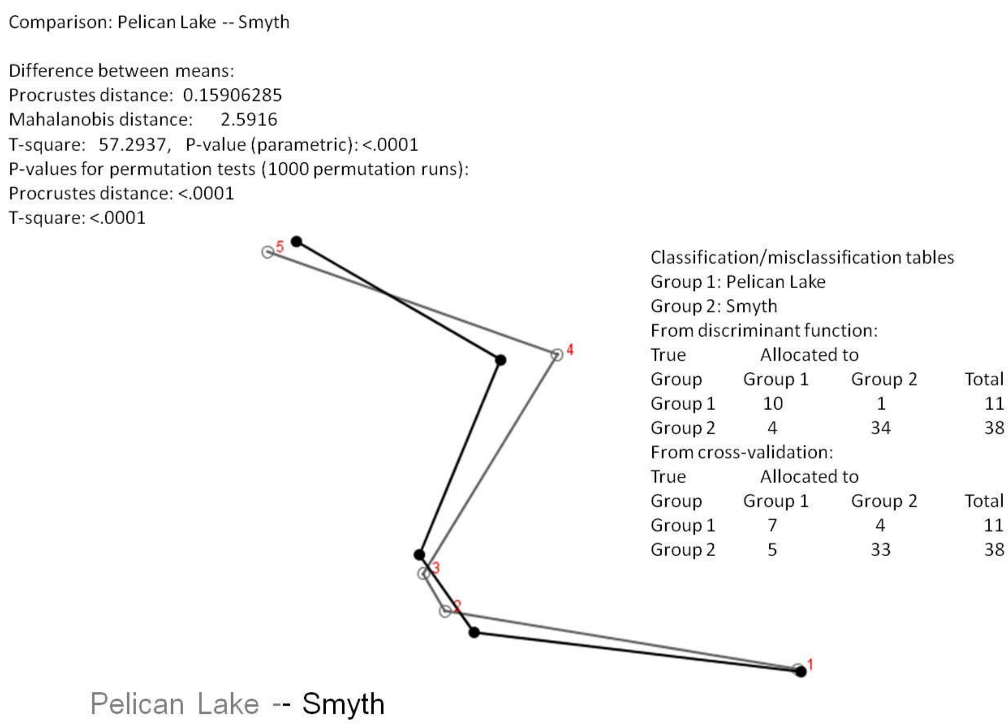


Figure B.54 DFA Results between Pelican Lake (light) and Smyth (dark).

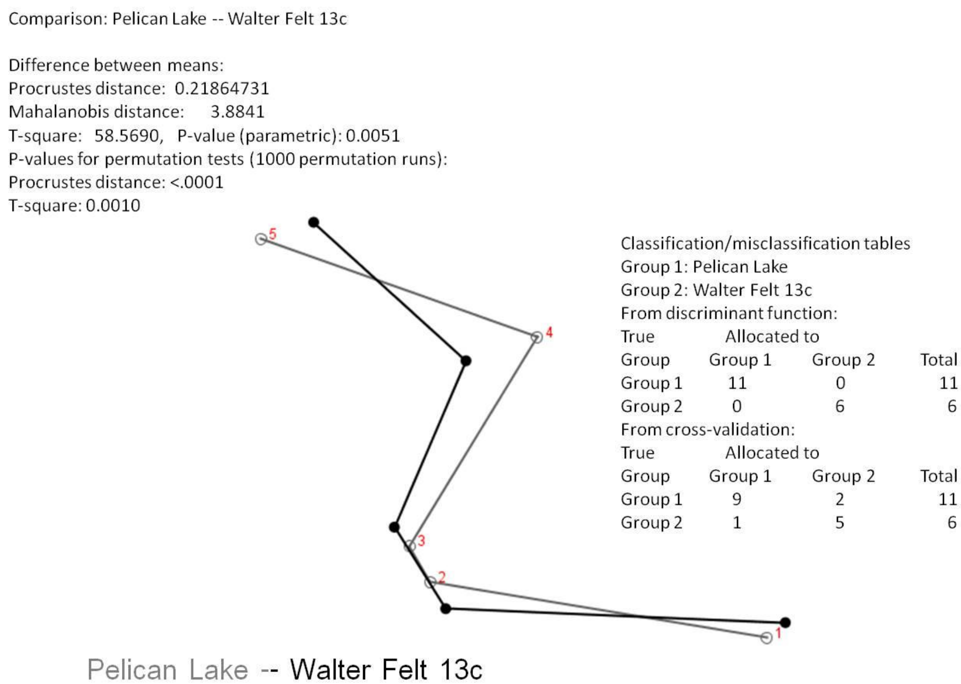


Figure B.55 DFA Results between Pelican Lake (light) and Walter Felt 13c (dark).

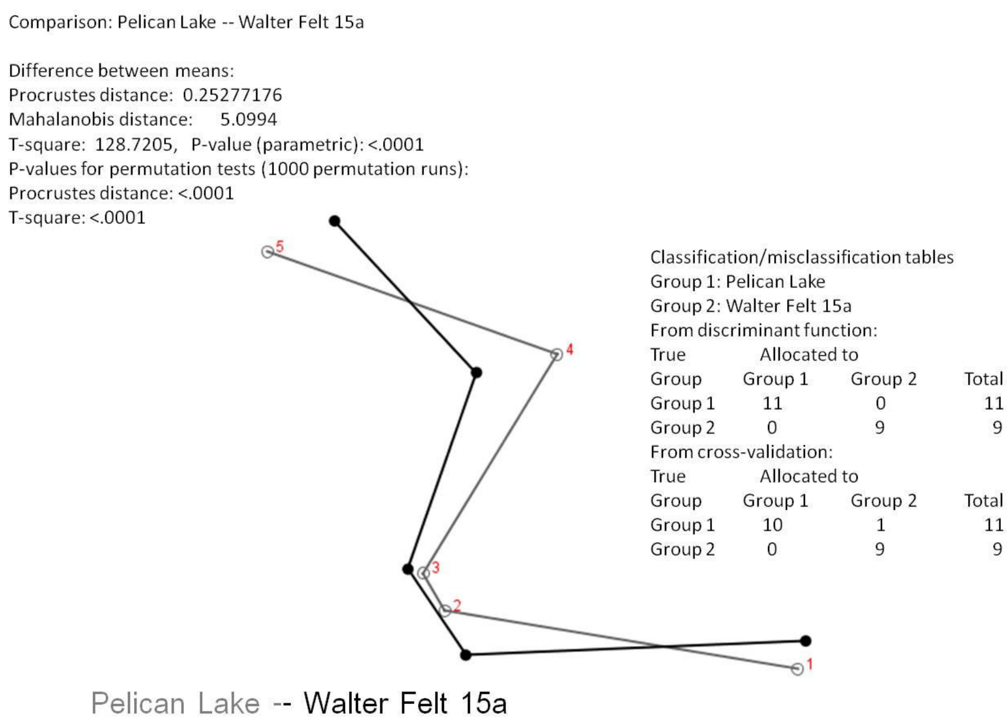


Figure B.56 DFA Results between Pelican Lake (light) and Walter Felt 15a (dark).

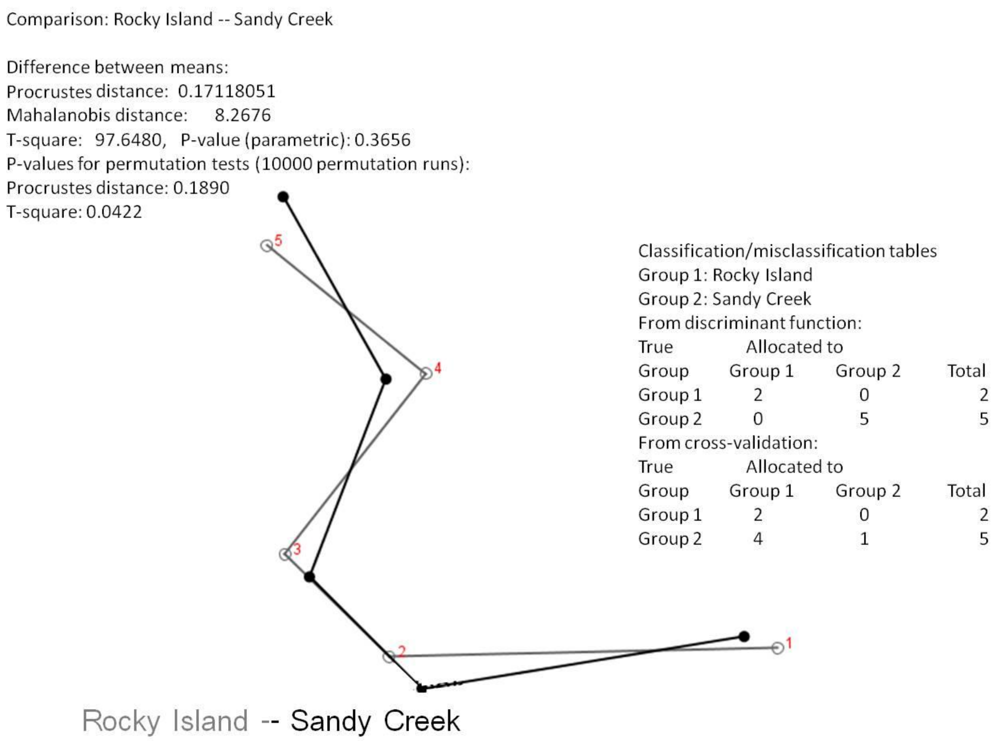


Figure B.57 DFA Results between Rocky Island (light) and Sandy Creek (dark).

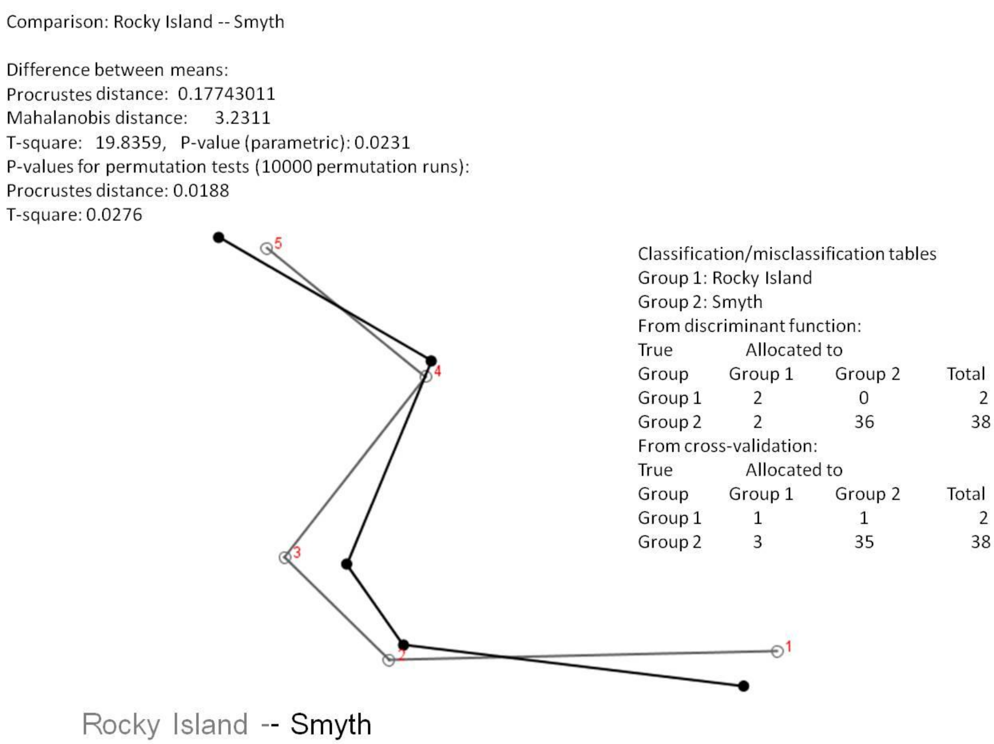
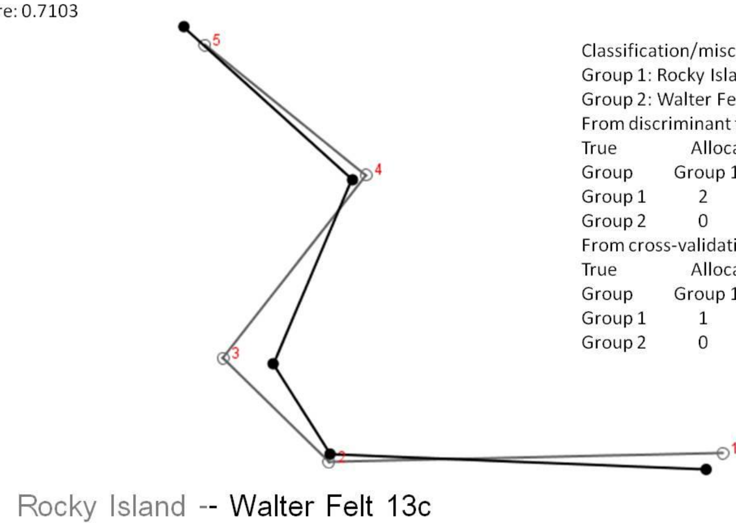


Figure B.58 DFA Results between Rocky Island (light) and Smyth (dark).

Comparison: Rocky Island -- Walter Felt 13c

Difference between means:
Procrustes distance: 0.11584580
Mahalanobis distance: 5.3296
T-square: 42.6077, P-value (parametric): 0.6066
P-values for permutation tests (10000 permutation runs):
Procrustes distance: 0.5530
T-square: 0.7103



Classification/misclassification tables
Group 1: Rocky Island
Group 2: Walter Felt 13c
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	2	0	2
Group 2	0	6	6

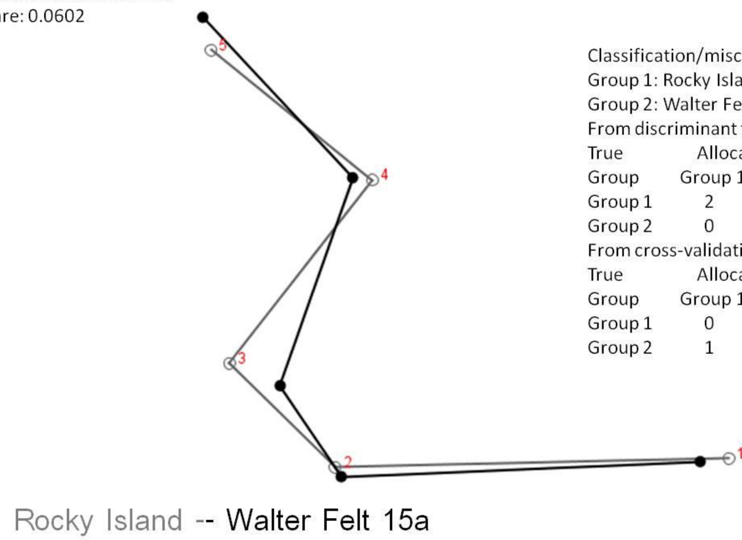
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	1	1	2
Group 2	0	6	6

Figure B.59 DFA Results between Rocky Island (light) and Walter Felt 13c (dark).

Comparison: Rocky Island -- Walter Felt 15a

Difference between means:
Procrustes distance: 0.13499657
Mahalanobis distance: 7.2136
T-square: 85.1507, P-value (parametric): 0.0481
P-values for permutation tests (10000 permutation runs):
Procrustes distance: 0.3221
T-square: 0.0602



Classification/misclassification tables
Group 1: Rocky Island
Group 2: Walter Felt 15a
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	2	0	2
Group 2	0	9	9

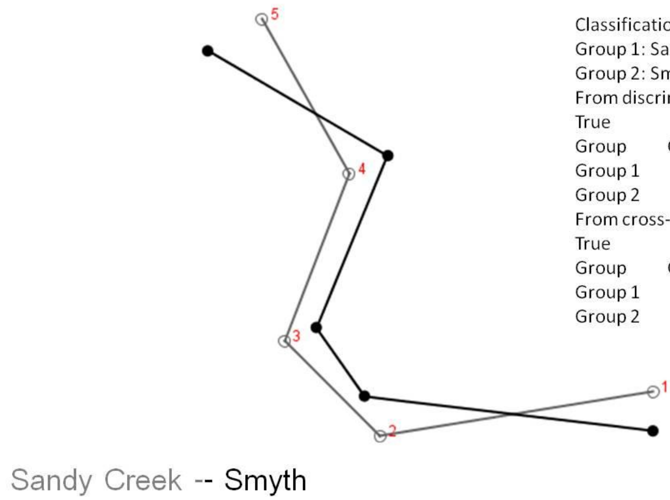
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	0	2	2
Group 2	1	8	9

Figure B.60 DFA Results between Rocky Island (light) and Walter Felt 15a (dark).

Comparison: Sandy Creek -- Smyth

Difference between means:
Procrustes distance: 0.21976485
Mahalanobis distance: 3.6091
T-square: 57.5554, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001



Classification/misclassification tables
Group 1: Sandy Creek
Group 2: Smyth
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	5	0	5
Group 2	0	38	38

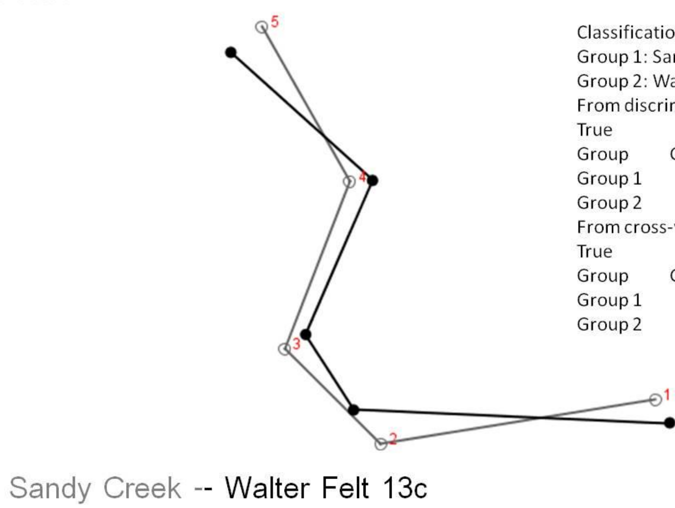
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	4	1	5
Group 2	2	36	38

Figure B.61 DFA Results between Sandy Creek (light) and Smyth (dark).

Comparison: Sandy Creek -- Walter Felt 13c

Difference between means:
Procrustes distance: 0.15837648
Mahalanobis distance: 5.2695
T-square: 75.7305, P-value (parametric): 0.0585
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.1080
T-square: 0.0990



Classification/misclassification tables
Group 1: Sandy Creek
Group 2: Walter Felt 13c
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	5	0	5
Group 2	0	6	6

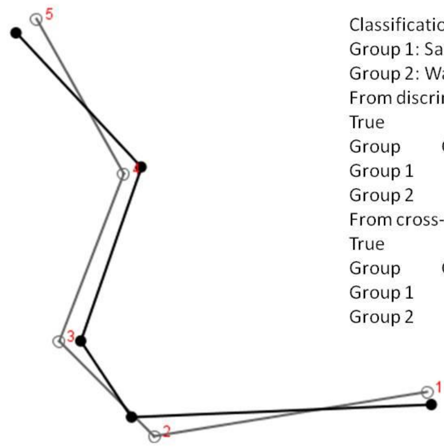
From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	4	1	5
Group 2	2	4	6

Figure B.62 DFA Results between Sandy Creek (light) and Walter Felt 13c (dark).

Comparison: Sandy Creek -- Walter Felt 15a

Difference between means:
Procrustes distance: 0.10744188
Mahalanobis distance: 4.2167
T-square: 57.1511, P-value (parametric): 0.0202
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.2410
T-square: 0.0210



Classification/misclassification tables
Group 1: Sandy Creek
Group 2: Walter Felt 15a
From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	5	0	5
Group 2	0	9	9

From cross-validation:

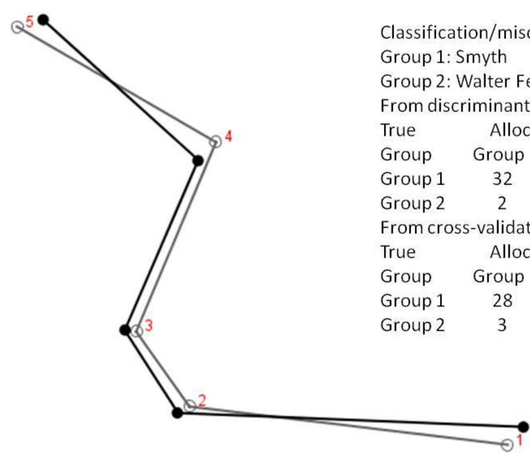
True Group	Allocated to Group 1	Group 2	Total
Group 1	4	1	5
Group 2	2	7	9

Sandy Creek -- Walter Felt 15a

Figure B.63 DFA Results between Sandy Creek (light) and Walter Felt 15a (dark).

Comparison: Smyth -- Walter Felt 13c

Difference between means:
Procrustes distance: 0.09399952
Mahalanobis distance: 1.7800
T-square: 16.4175, P-value (parametric): 0.0457
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0670
T-square: 0.0570



Classification/misclassification tables
Group 1: Smyth
Group 2: Walter Felt 13c
From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	32	6	38
Group 2	2	4	6

From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	28	10	38
Group 2	3	3	6

Smyth-- Walter Felt 13c

Figure B.64 DFA Results between Smyth (light) and Walter Felt 13c (dark).

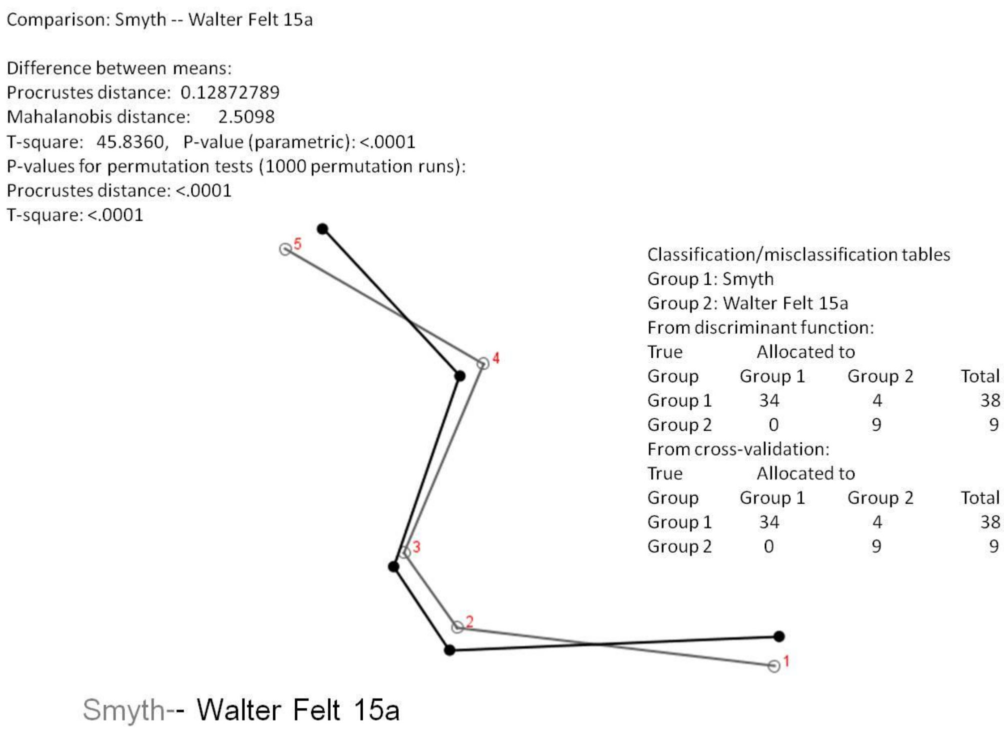


Figure B.65 DFA Results between Smyth (light) and Walter Felt 15a (dark).

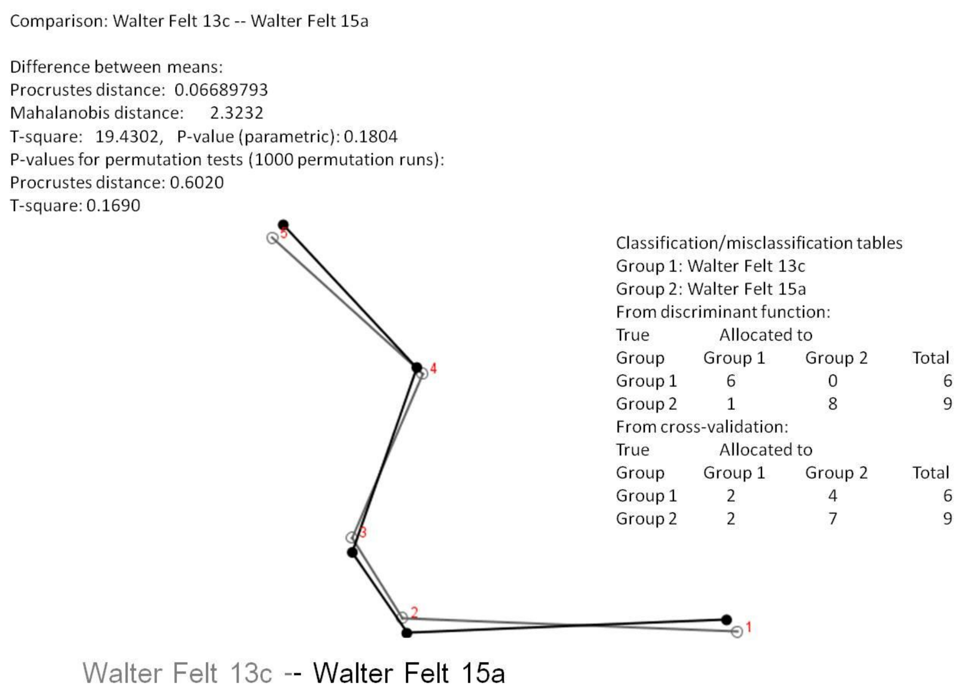


Figure B.66 DFA Results between Walter Felt 13c (light) and Walter Felt 15a (dark).

Appendix C: Results of the UPGAMA Cluster Analysis on Assemblages

List of Figures

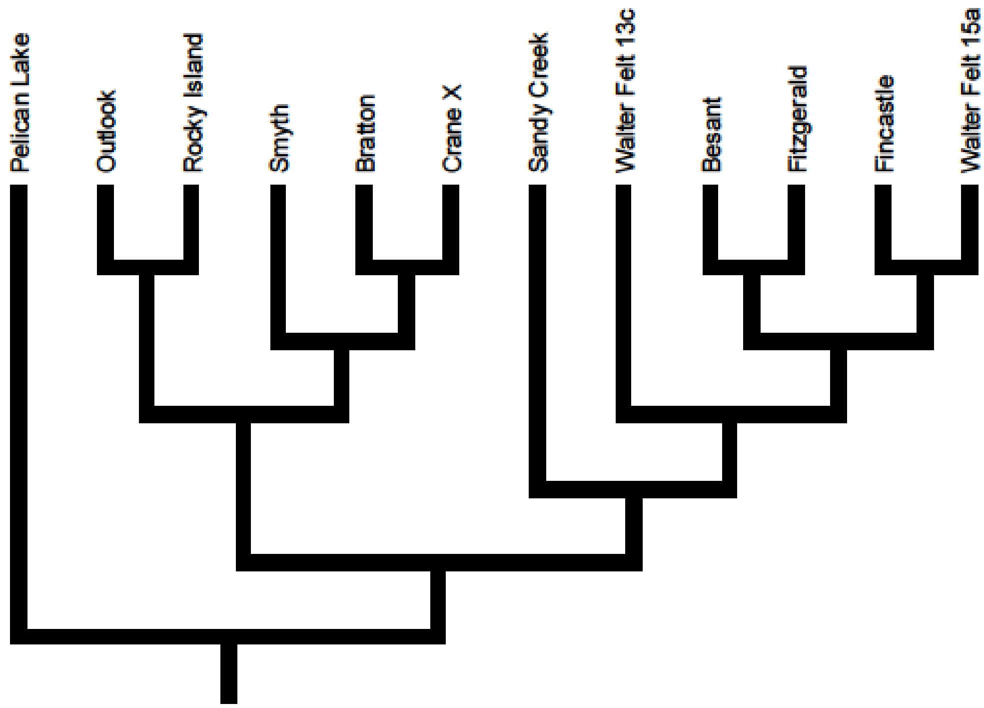


Figure C.1 Diagrammatic Representation of CVA data derived in Mesquite (2011). Image based on Mahalanobis and Procrustes Distances and associated p-values

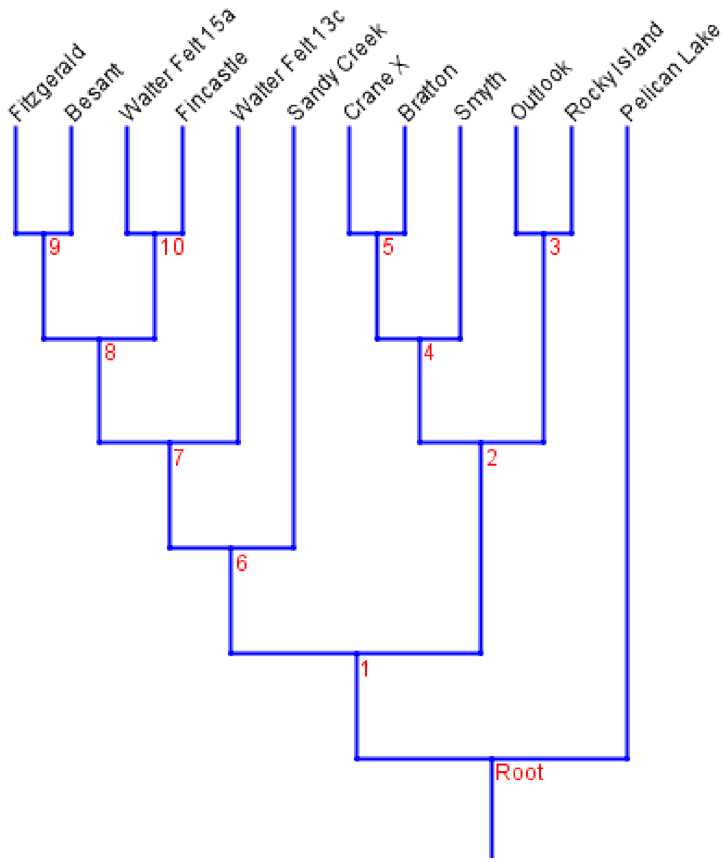


Figure C.2 C.1 merged with the shape data in MorhpoJ (2012).

The average shape of the projectile point styles, the nodes, and the shape changes between them will be displayed in the remainder of the appendix all in reference to C.2. Landmarks are in red

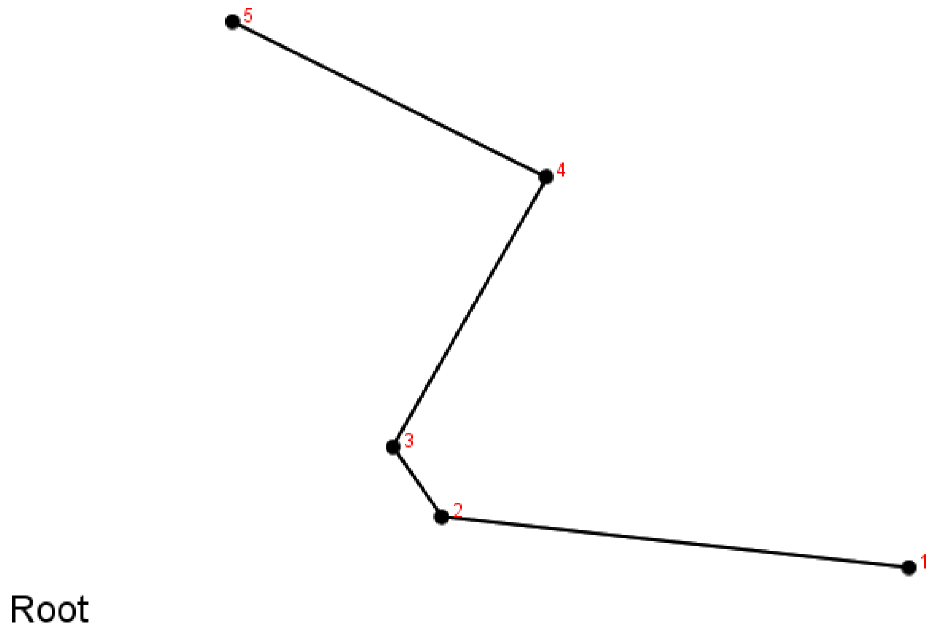


Figure C.3 Average shape at the Root Node.

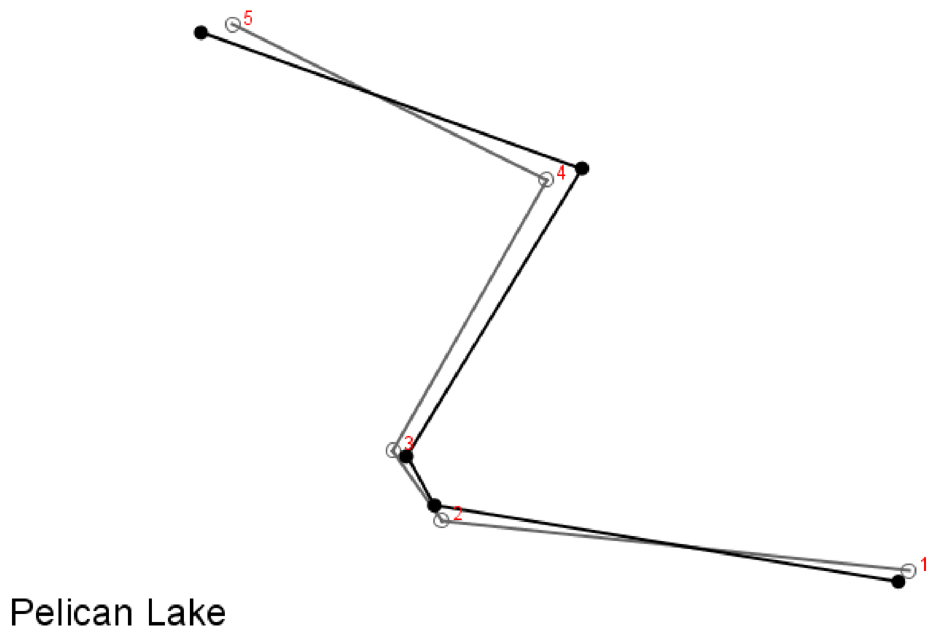


Figure C.4 Shape change between Root (light) and Pelican Lake (dark).

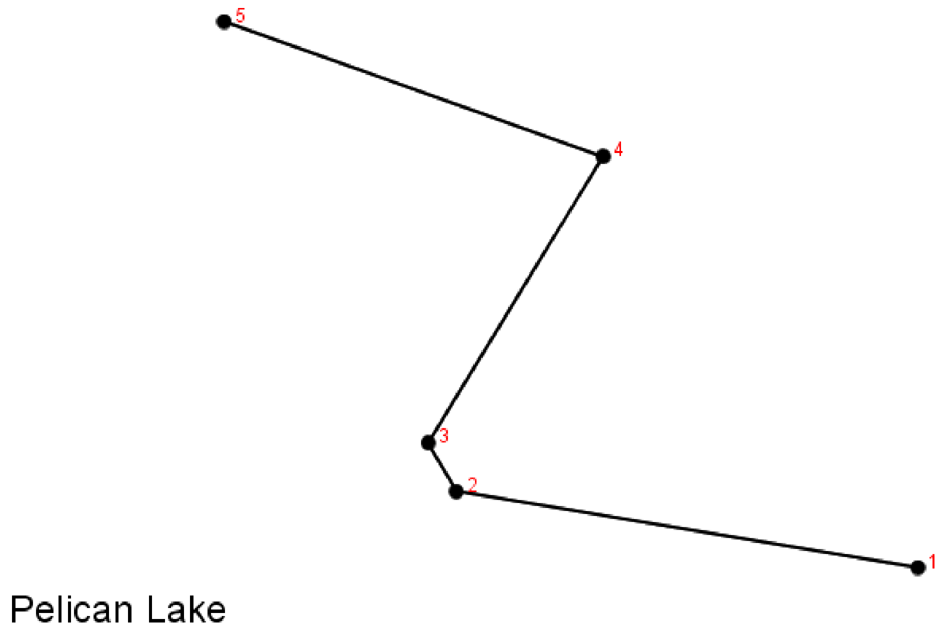


Figure C.5 Average shape for Pelican Lake.

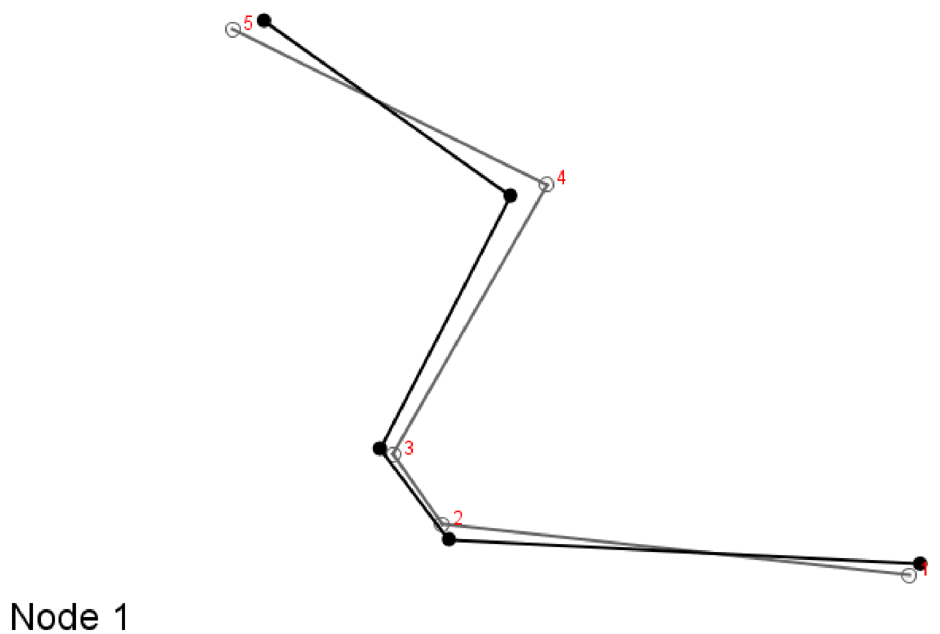


Figure C.6 Shape change between Root (light) and Node 1 (dark).

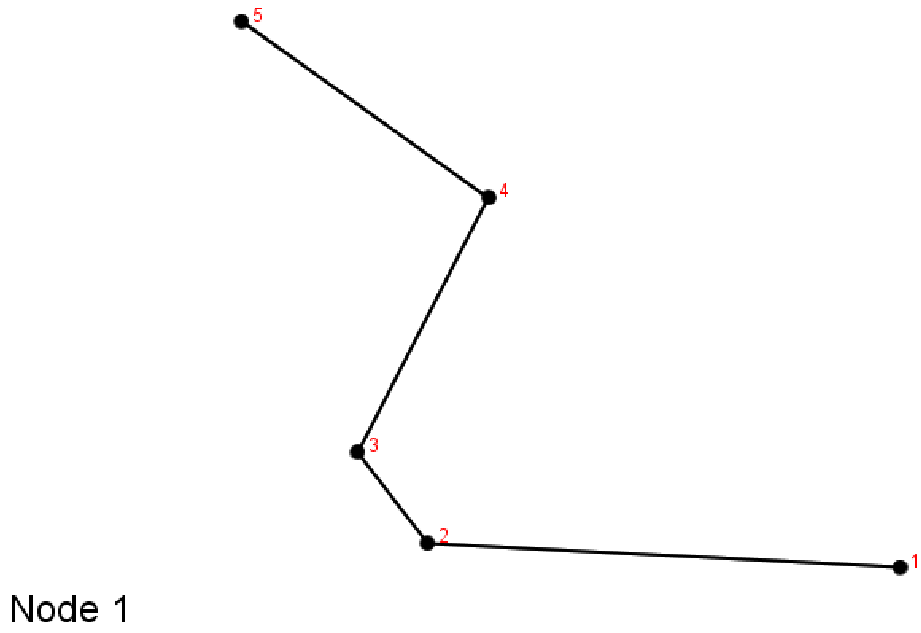


Figure C.7 Average shape for Node 1.

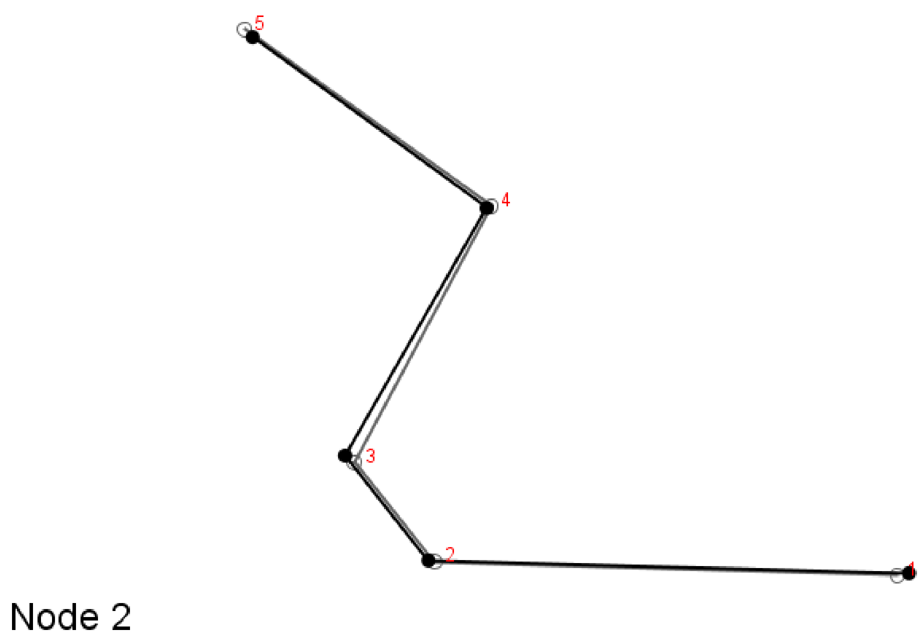


Figure C.8 Shape change between Node 1 (light) and Node 2 (dark).

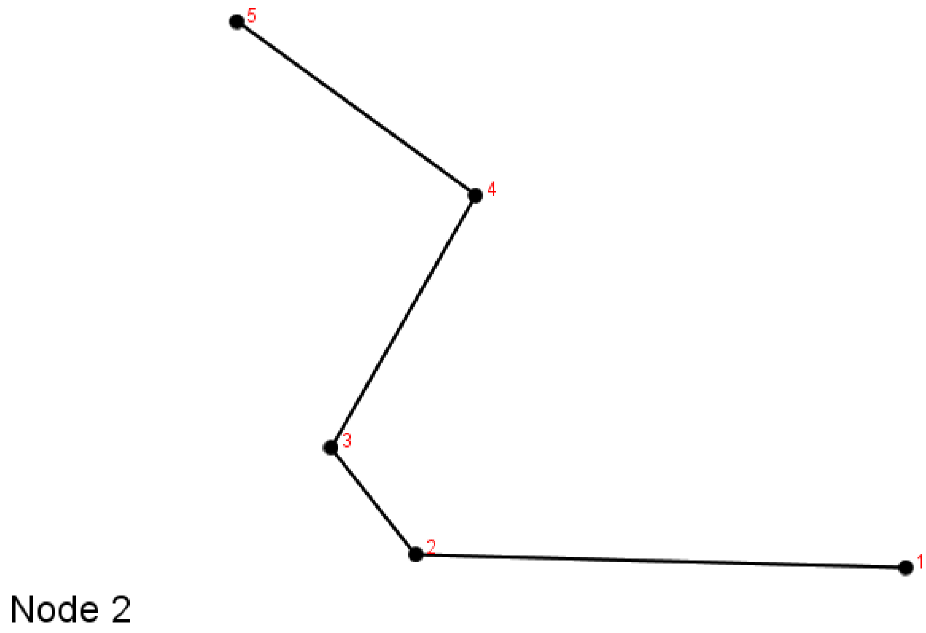


Figure C.9 Average shape for Node 2.

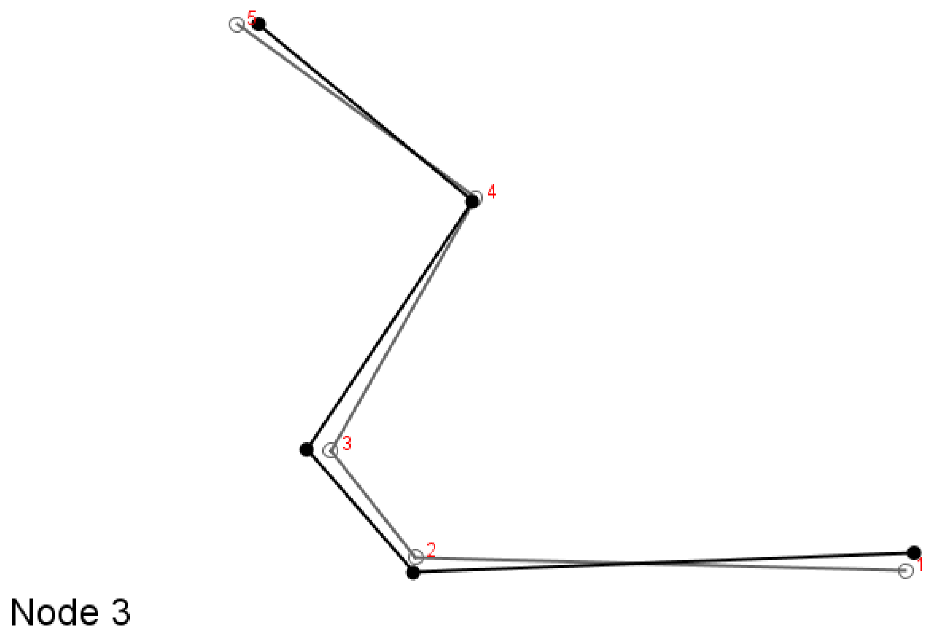


Figure C.10 Shape change between Node 2 (light) and Node 3 (dark).

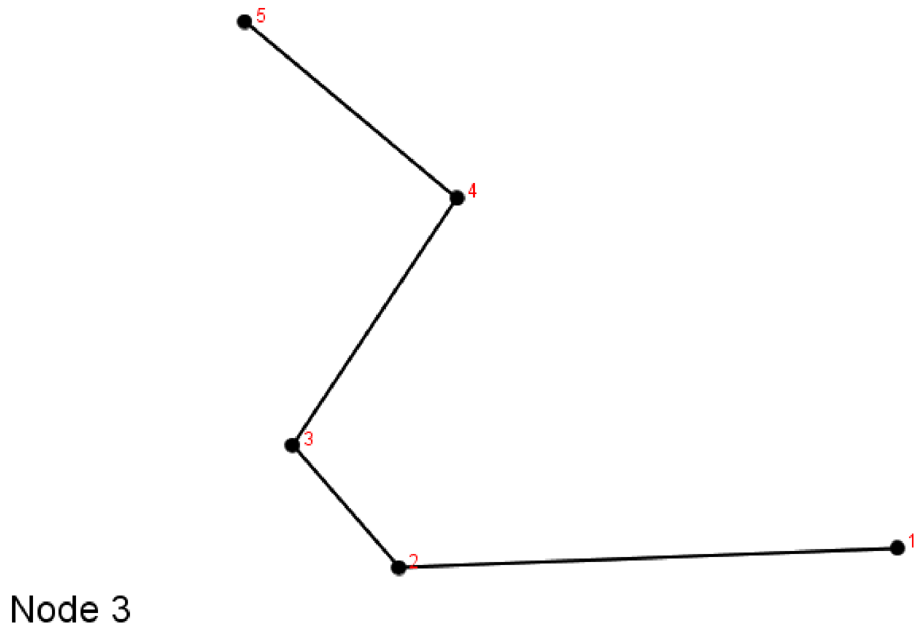


Figure C.11 Average shape for Node 3.

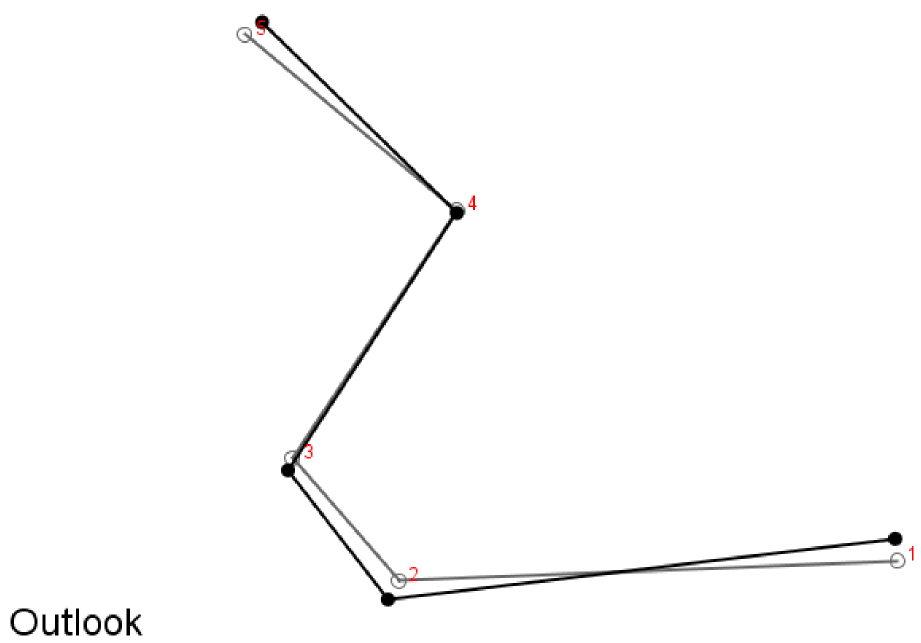


Figure C.12 Shape change between Node 3 (light) and Outlook (dark).

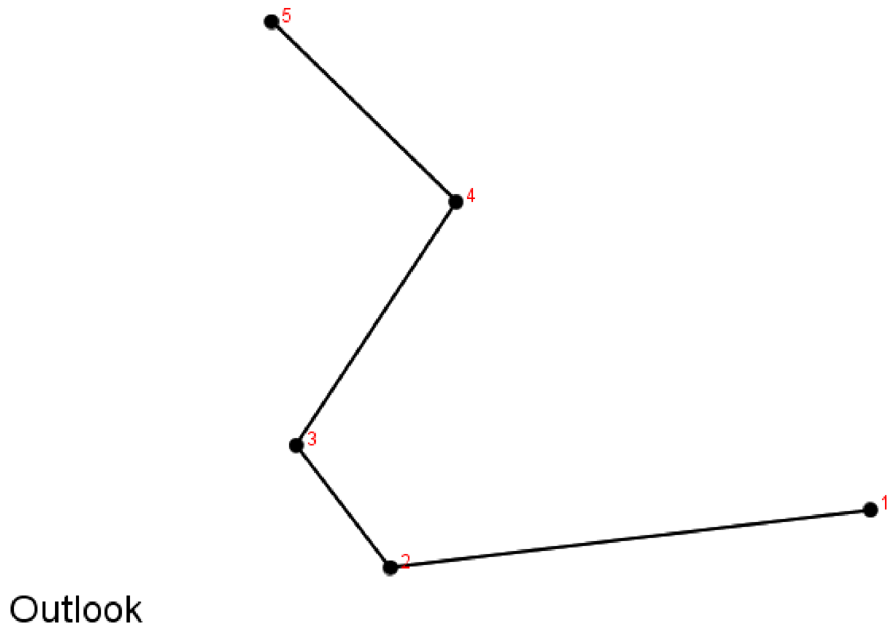


Figure C.13 Average shape for Outlook.

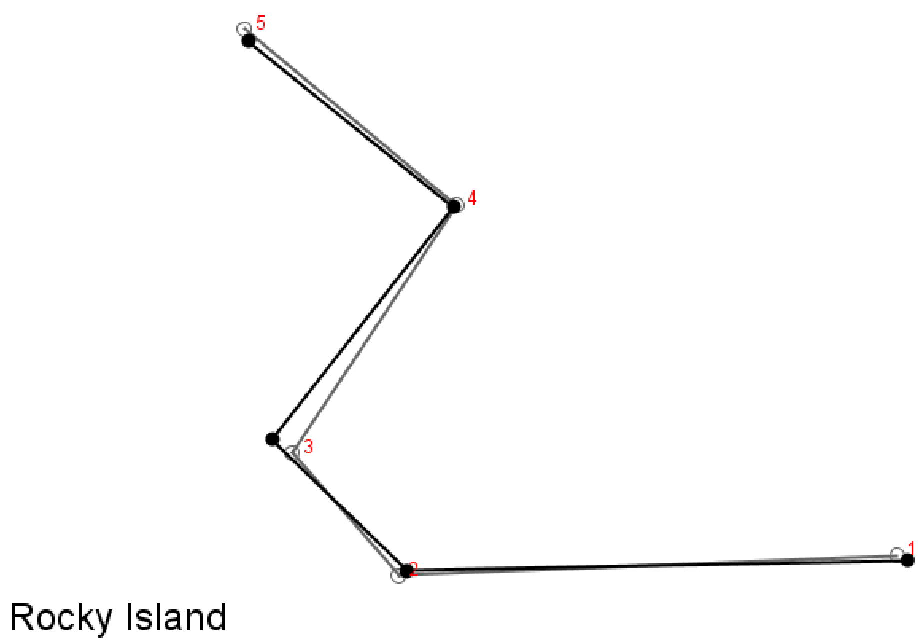


Figure C.14 Shape change between Node 3 (light) and Rocky Island (dark).

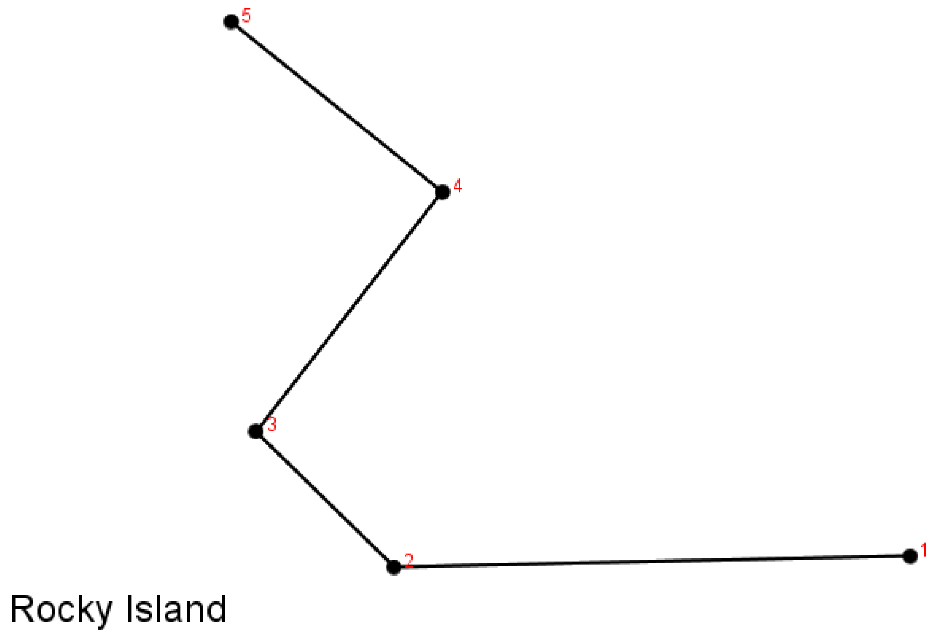


Figure C.15 Average shape for Rocky Island.

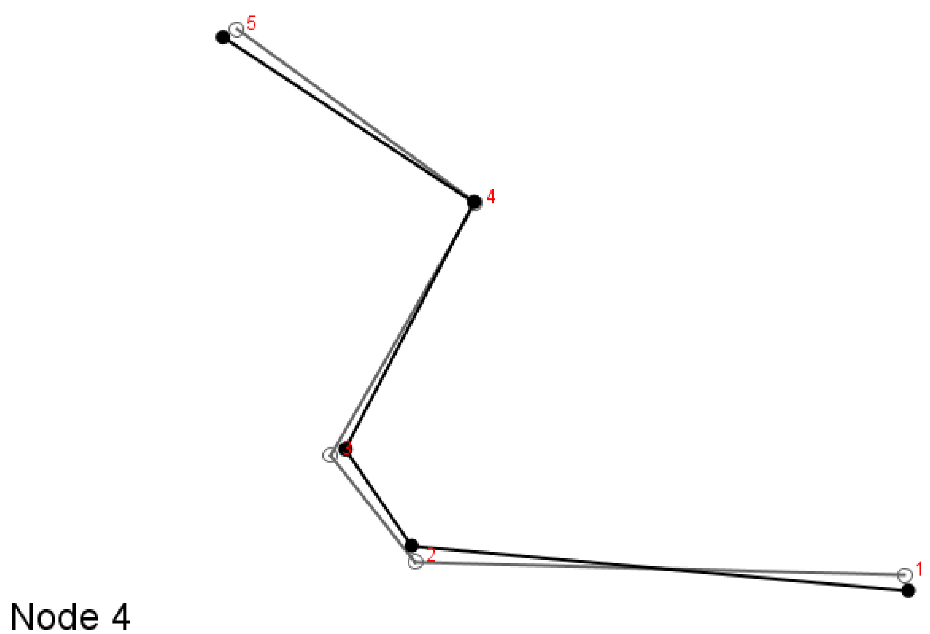


Figure C.16 Shape change between Node 2 (light) and Node 4 (dark).

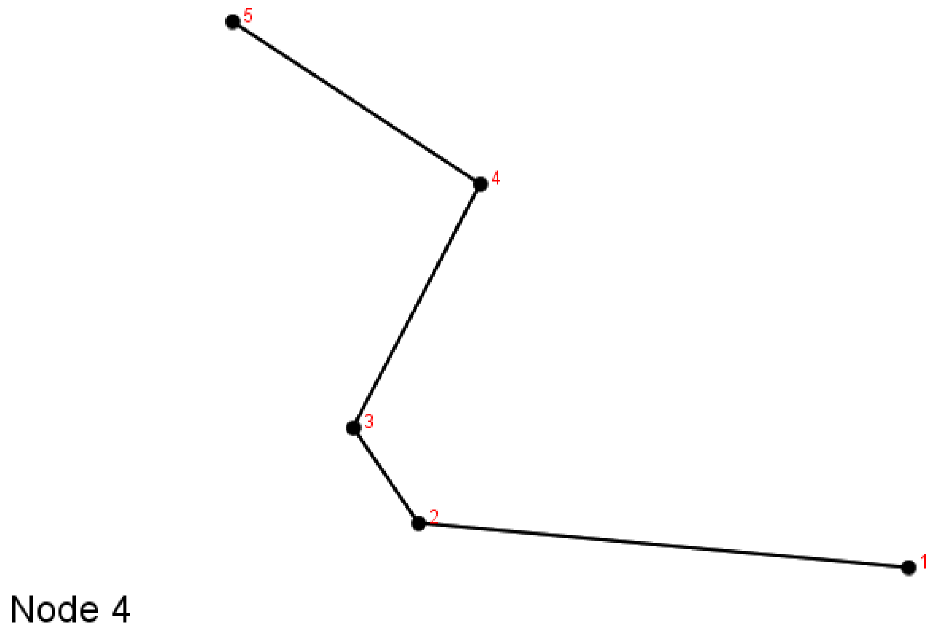


Figure C.17 Average shape for Node 4.

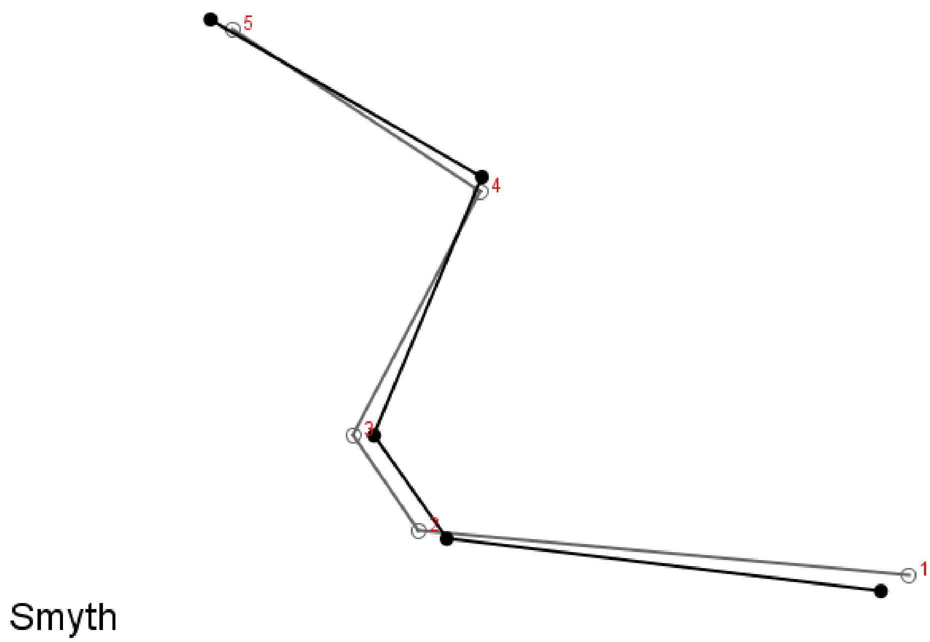


Figure C.18 Shape change between Node 4 (light) and Smyth (dark).

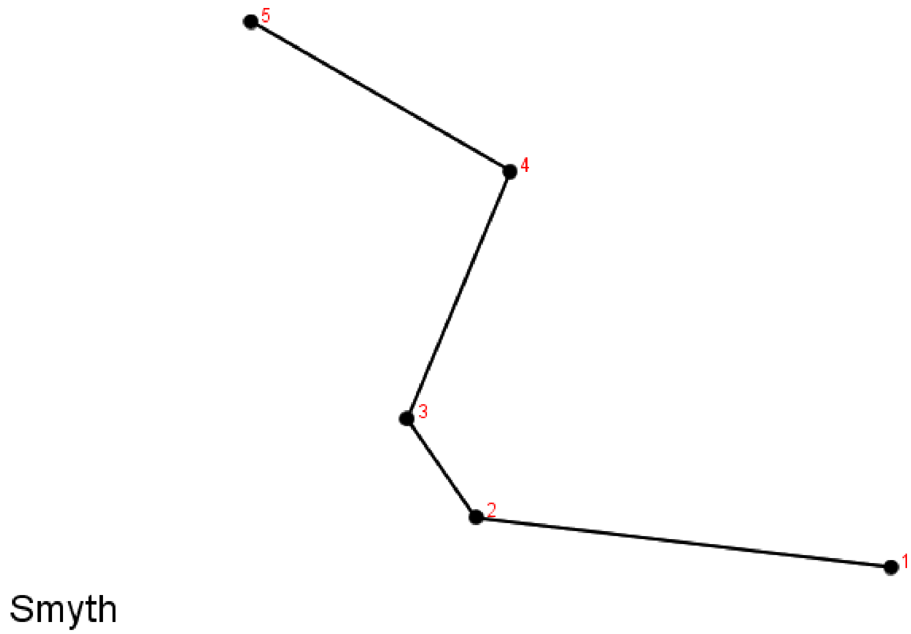


Figure C.19 Average shape for Smyth.

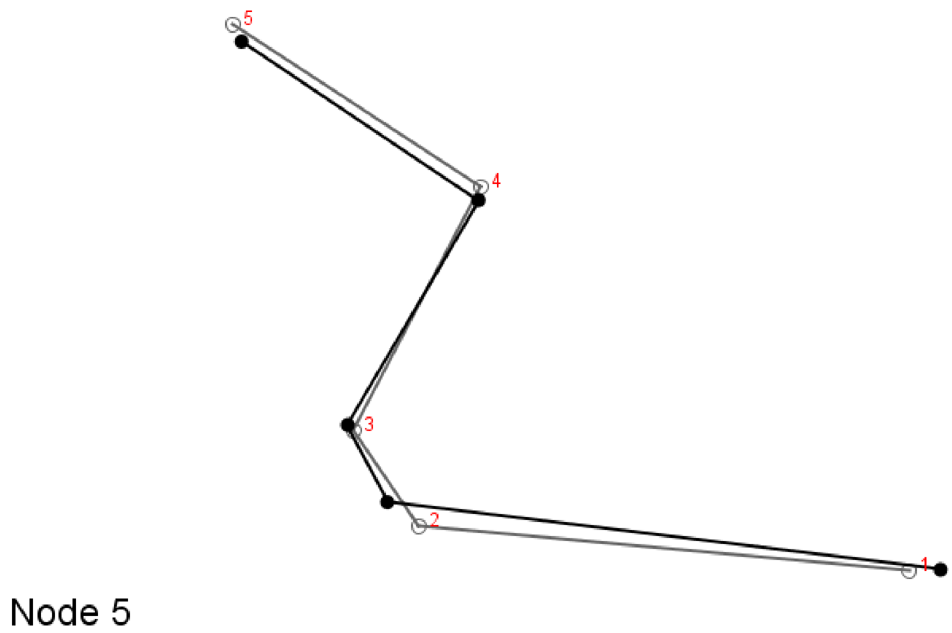


Figure C.20 Shape change between Node 4 (light) and Node 5 (dark).

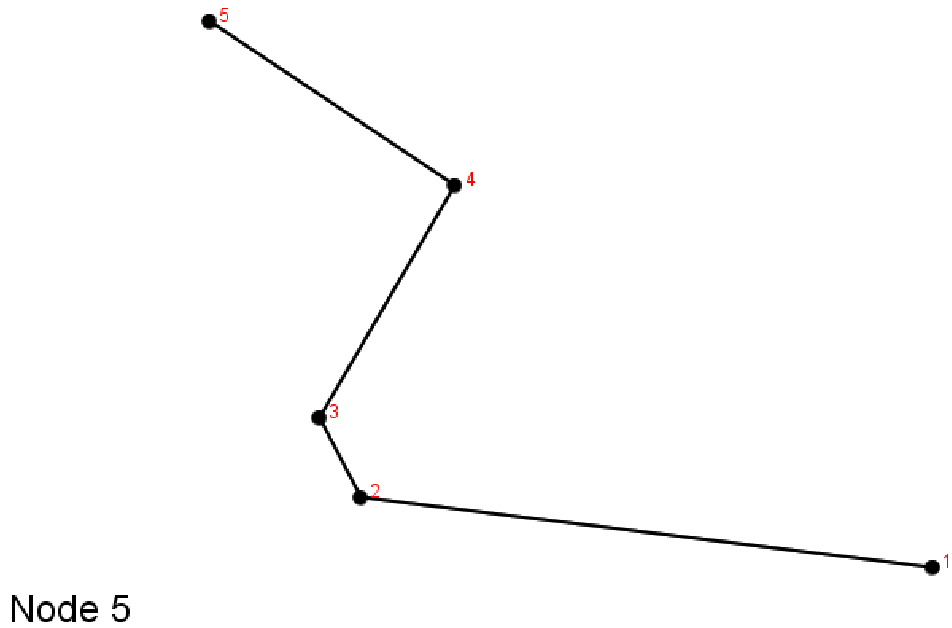


Figure C.21 Average shape for Node 5.

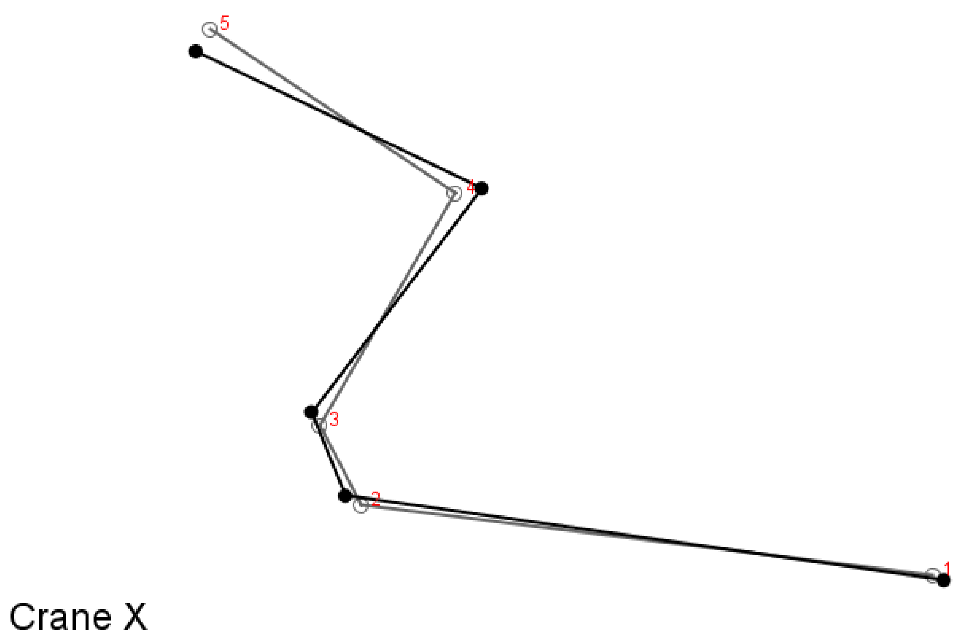


Figure C.22 Shape change between Node 5 (light) and Crane X (dark).

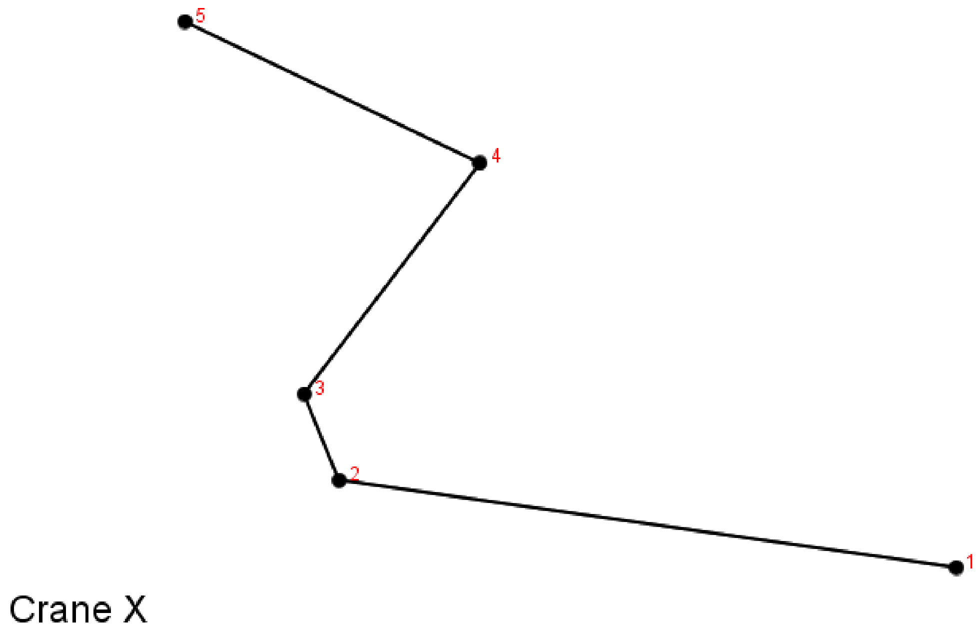


Figure C.23 Average shape for Crane X.

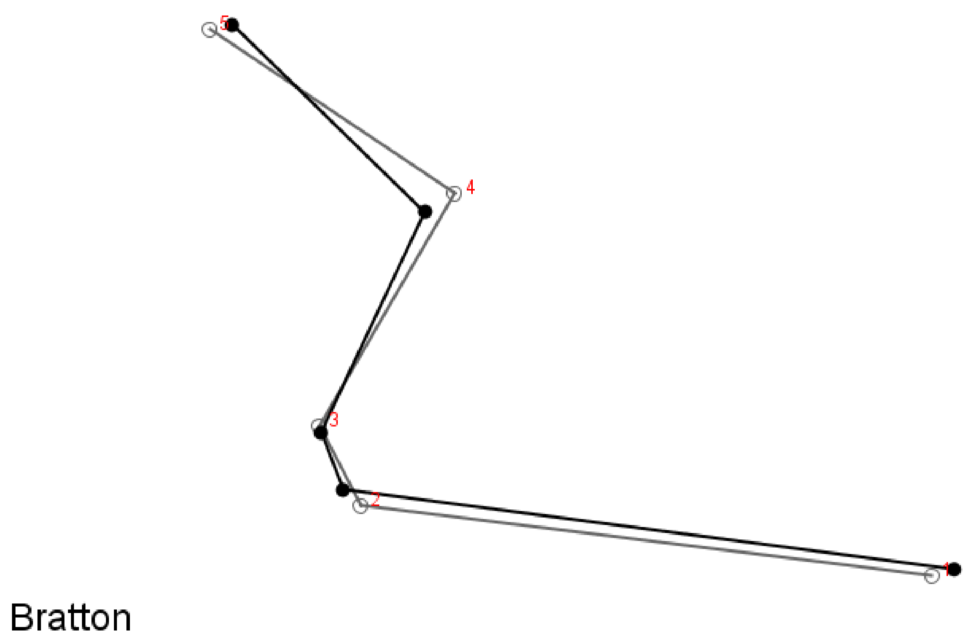


Figure C.24 Shape change between Node 5 (light) and Bratton (dark).

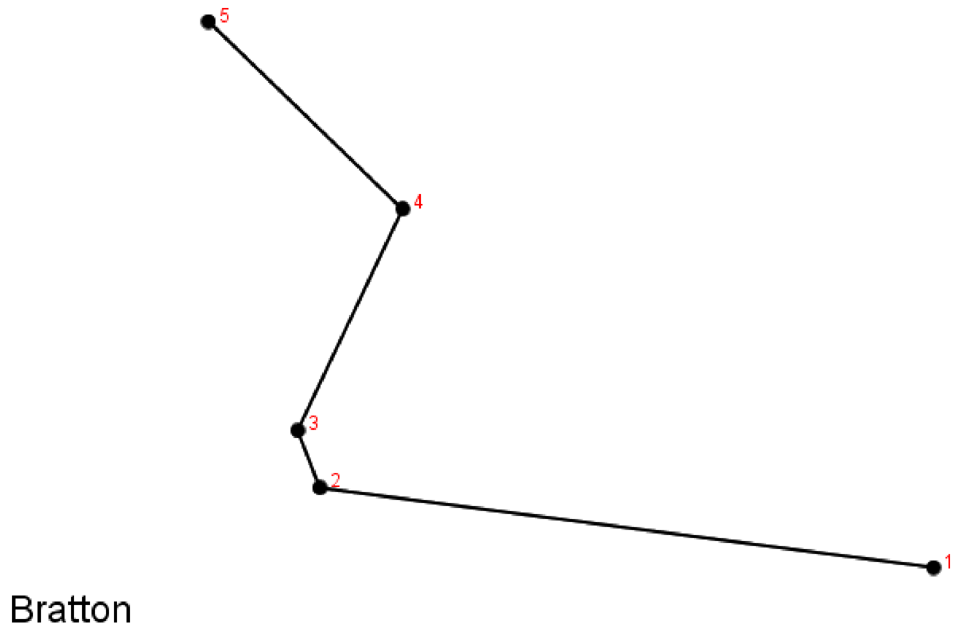


Figure C.25 Average shape for Bratton.

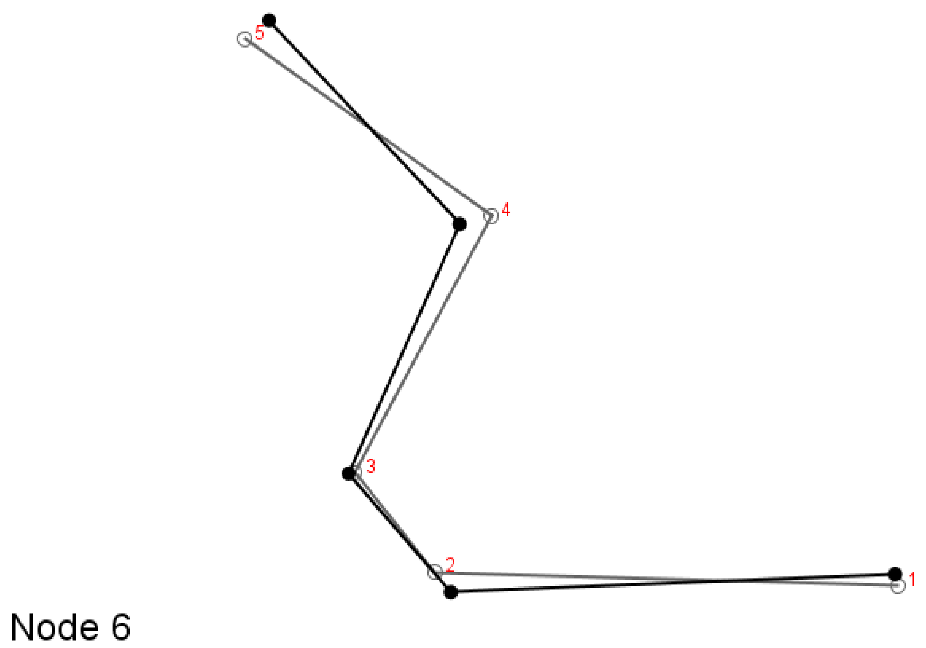


Figure C.26 Shape change between Node 1 (light) and Node 6 (dark).

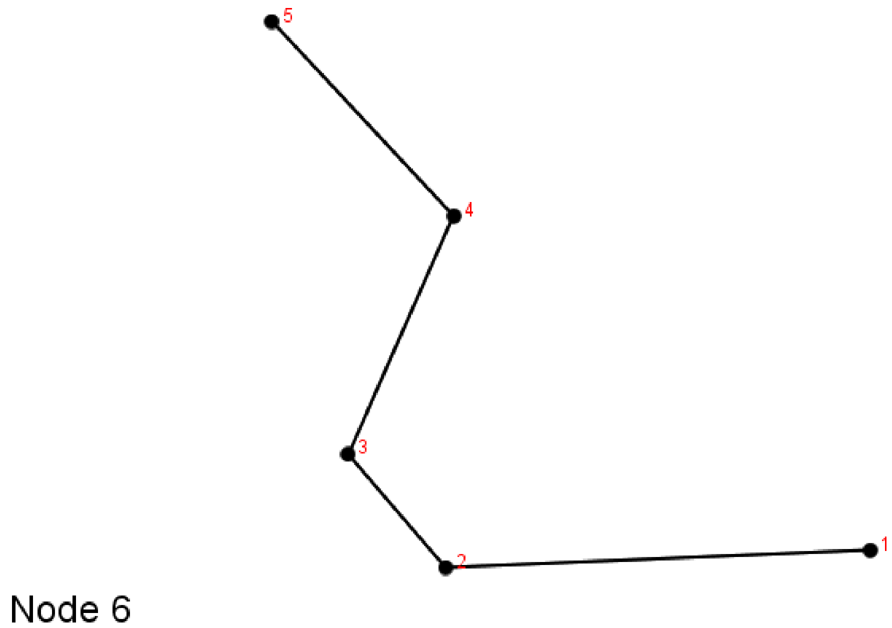


Figure C.27 Average shape for Node 6.

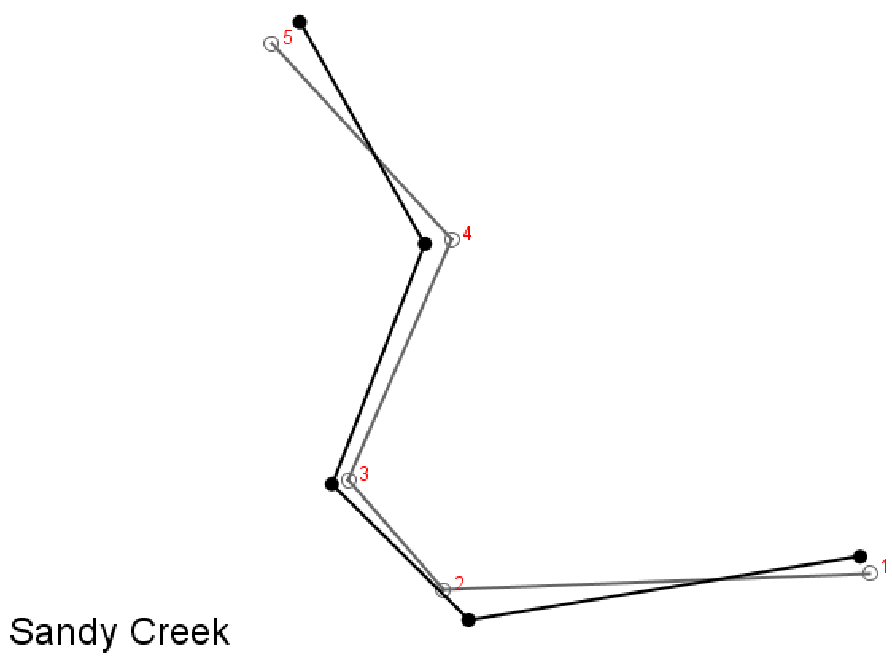


Figure C.28 Shape change between Node 6 (light) and Sandy Creek (dark).

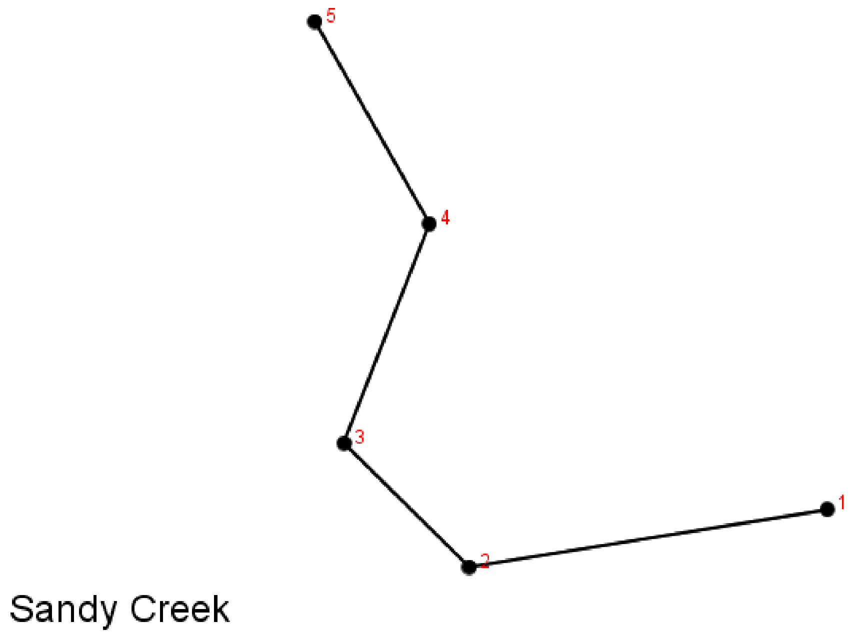


Figure C.29 Average shape for Sandy Creek.

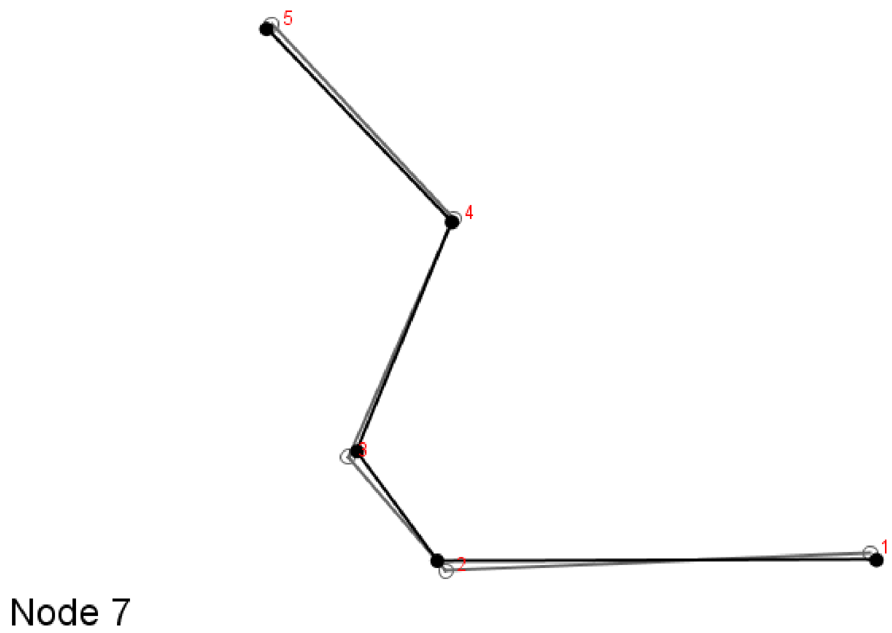


Figure C.30 Shape change between Node 6 (light) and Node 7 (dark).

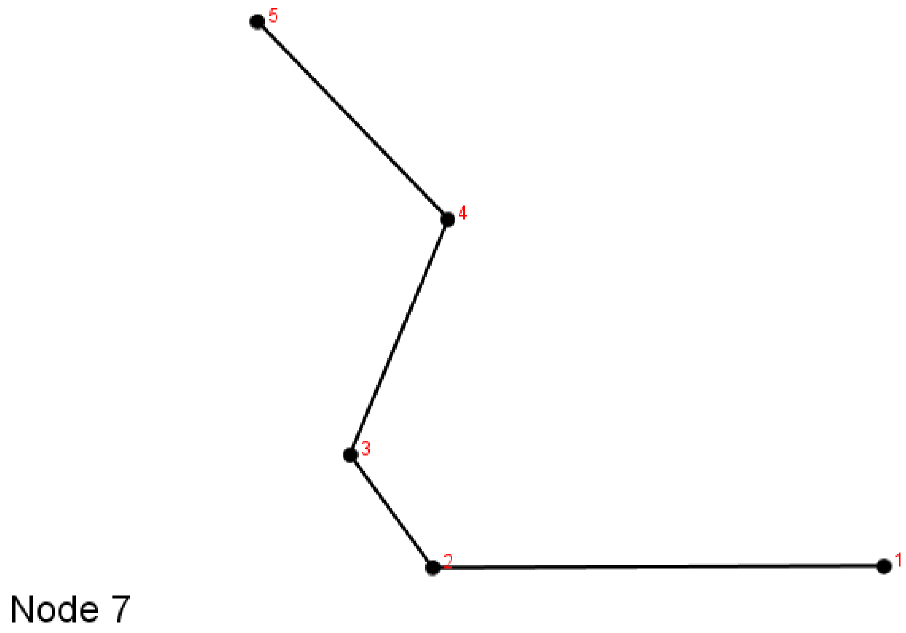


Figure C.31 Average shape for Node 7.

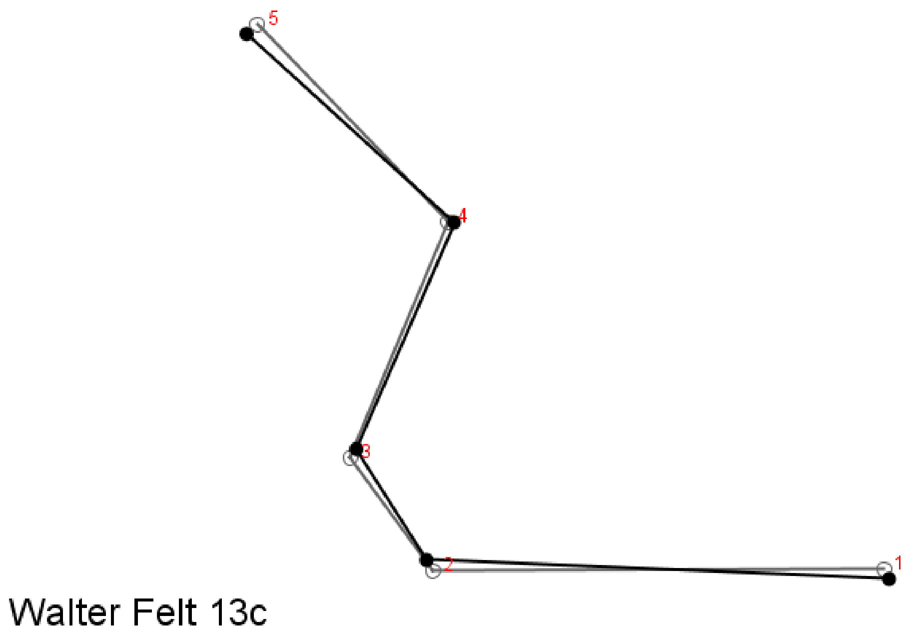


Figure C.32 Shape change between Node 7 (light) and Walter Felt 13c (dark).

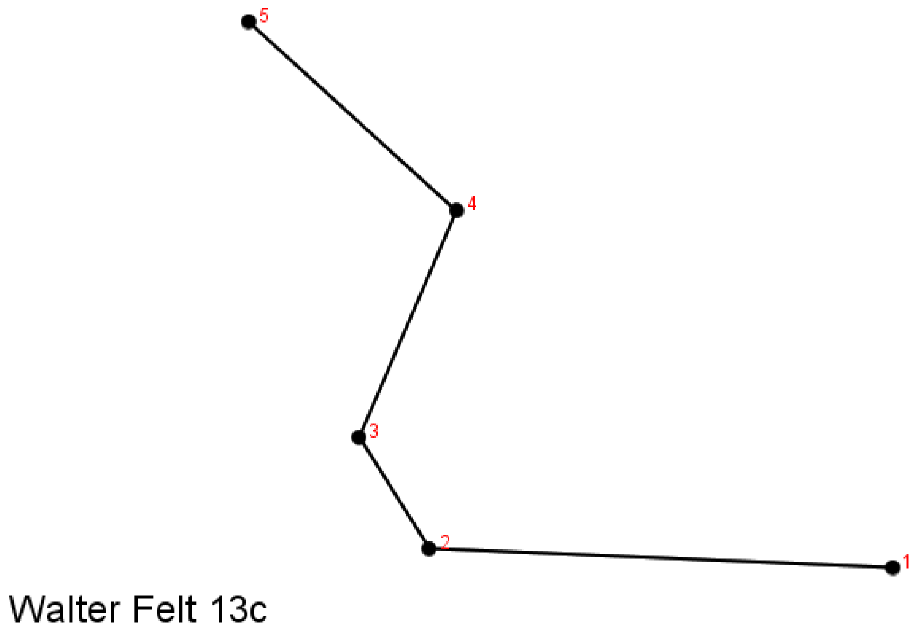


Figure C.33 Average shape for Walter Felt 13c.

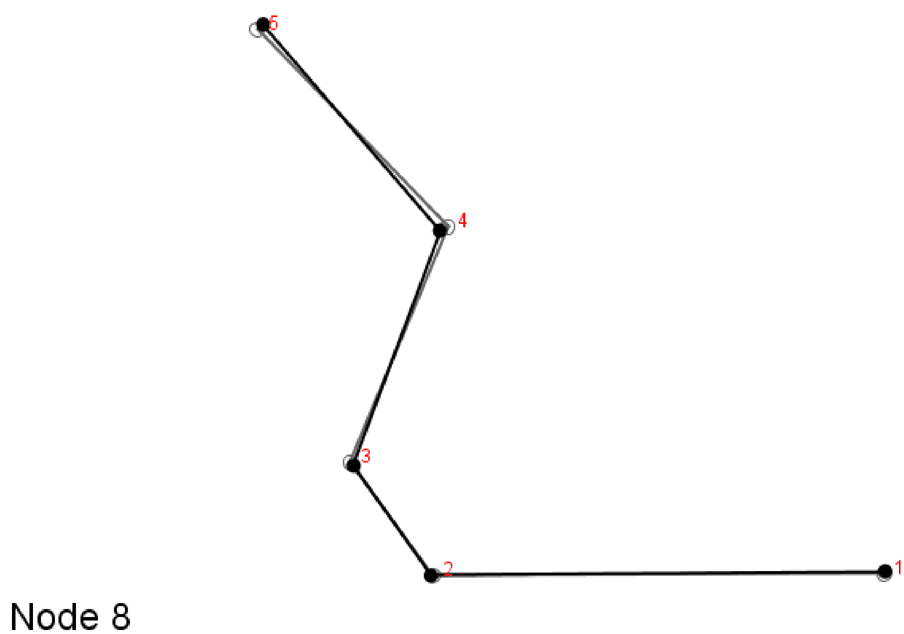


Figure C.34 Shape change between Node 7 (light) and Node 8 (dark).

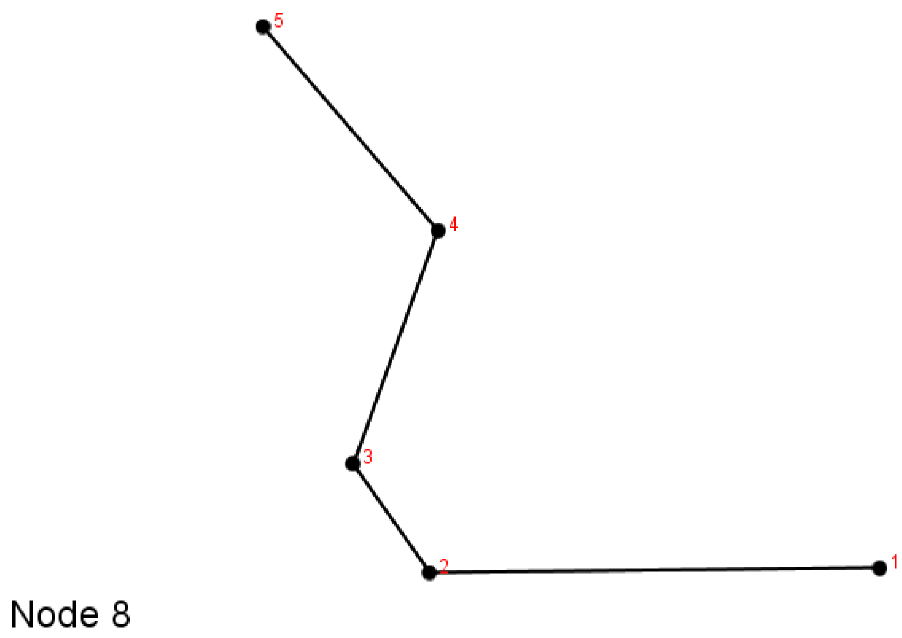


Figure C.35 Average shape for Node 8.

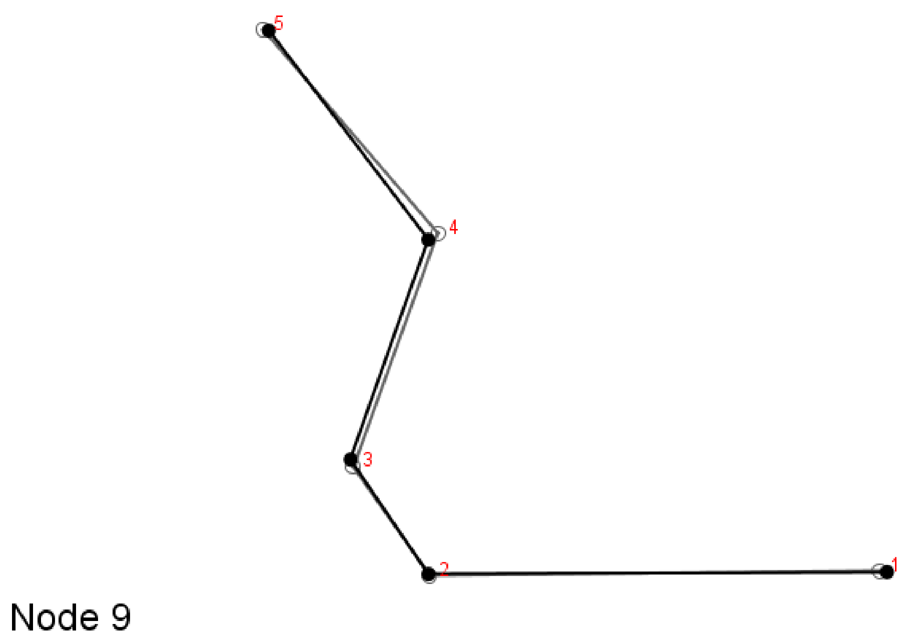


Figure C.36 Shape change between Node 8 (light) and Node 9 (dark).

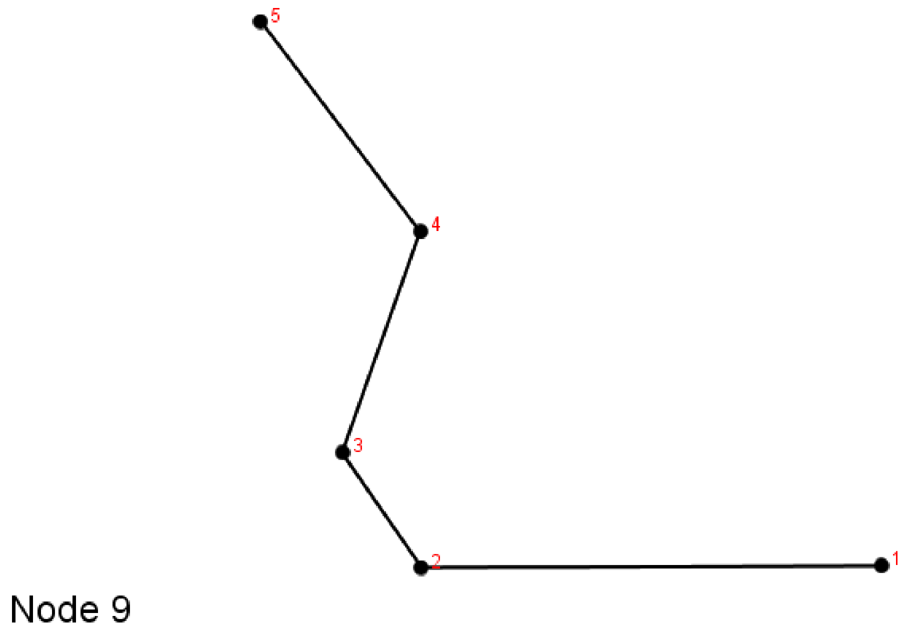


Figure C.37 Average shape for Node 9.

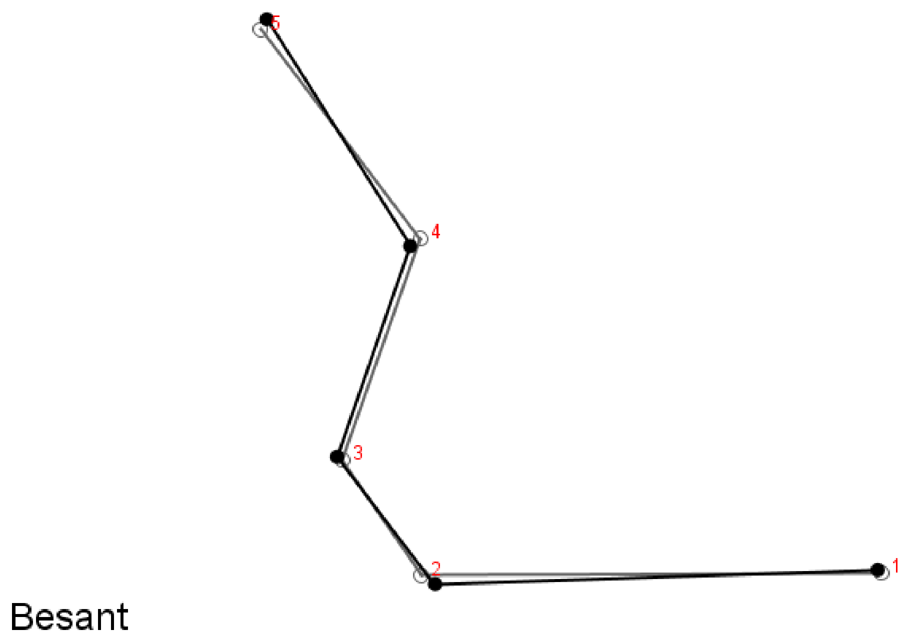


Figure C.38 Shape change between Node 9 (light) and Besant (dark).

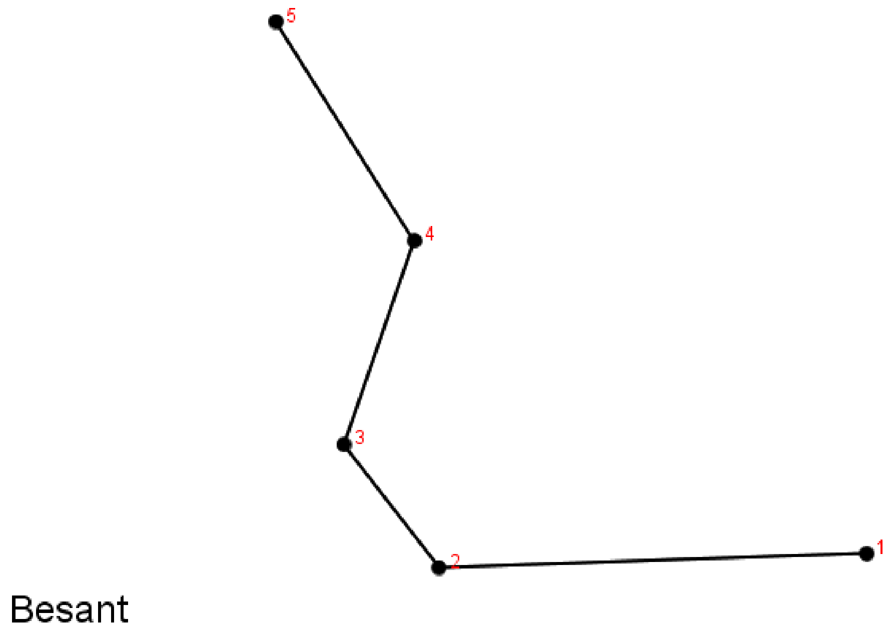


Figure C.39 Average shape for Besant.

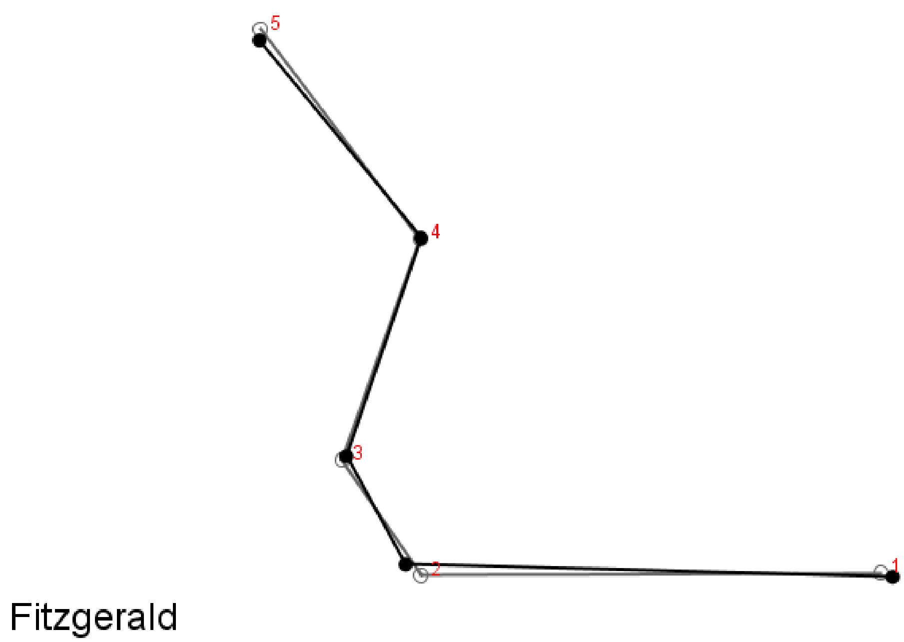


Figure C.40 Shape change between Node 9 (light) and Fitzgerald (dark).

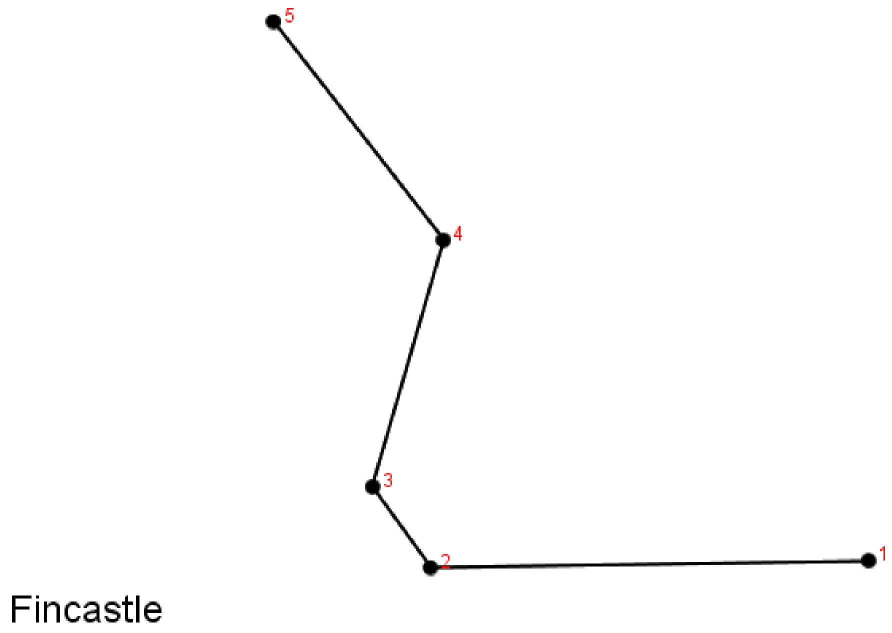


Figure C.41 Average shape for Fitzgerald.

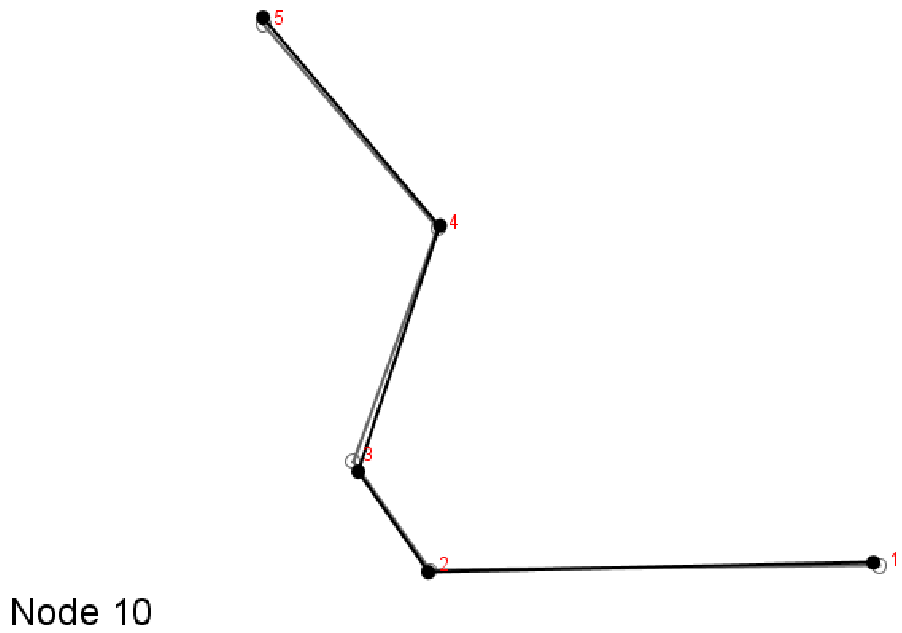


Figure C.42 Shape change between Node 8 (light) and Node 10 (dark).

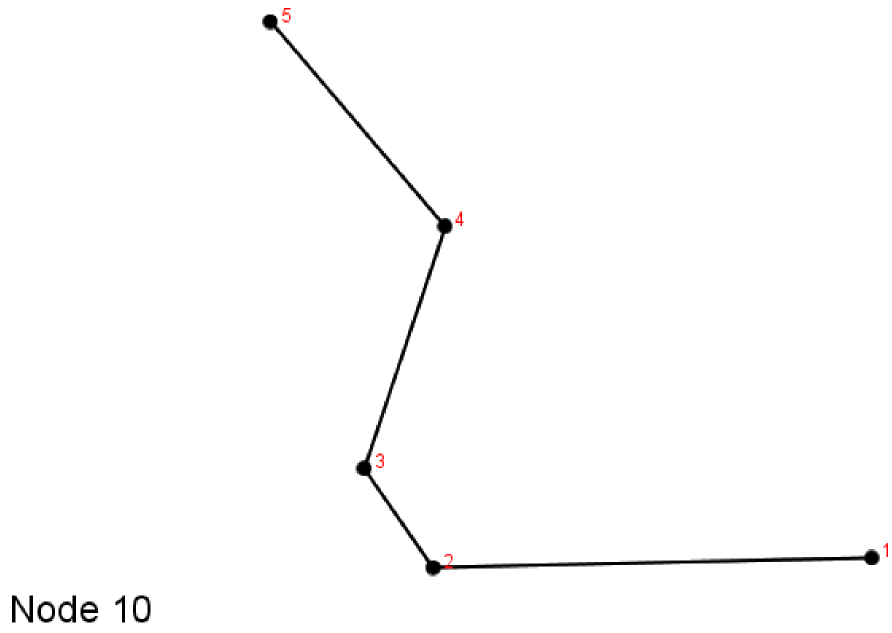


Figure C.43 Average shape for Node 10.

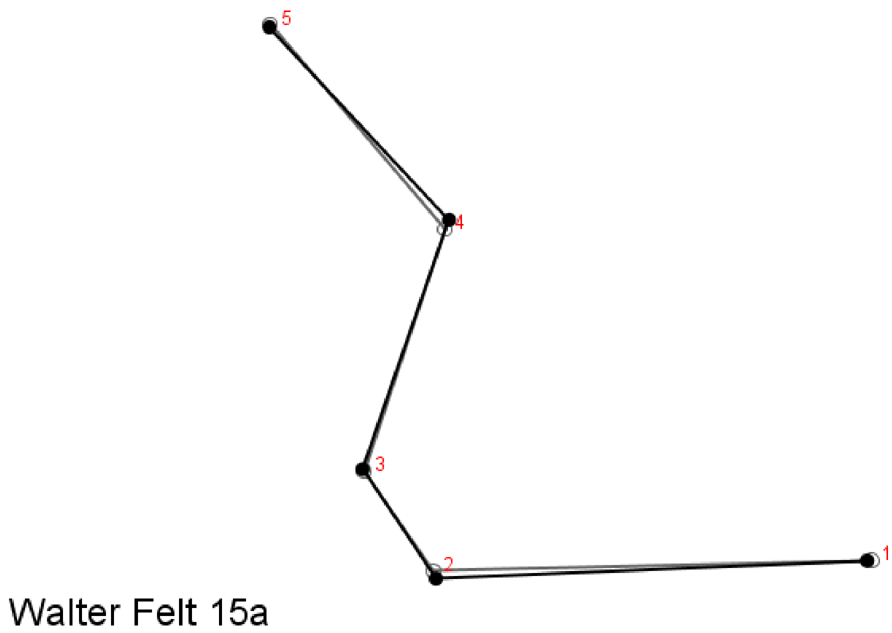


Figure C.44 Shape change between Node 10 (light) and Walter Felt 15a (dark).

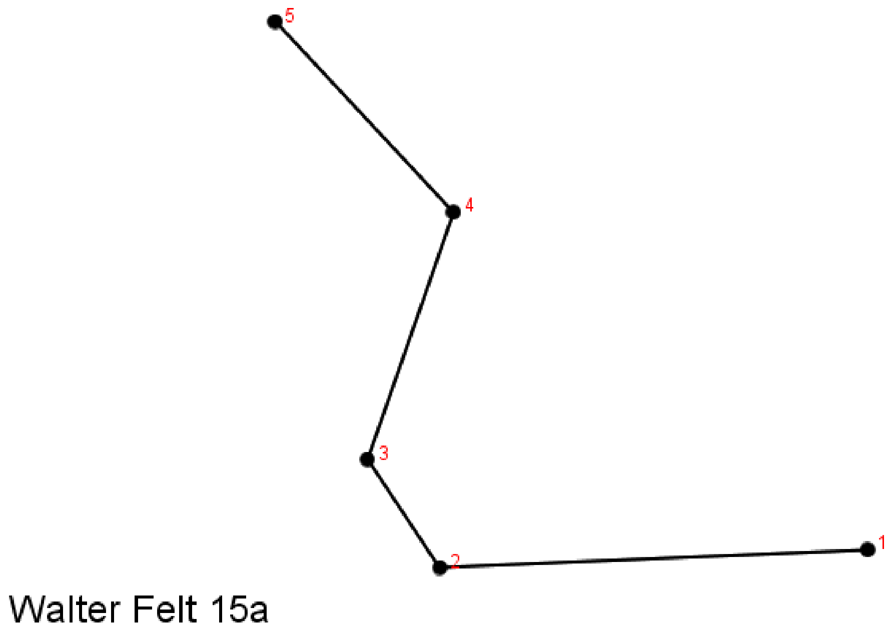


Figure C.45 Average shape for Walter Felt 15a.

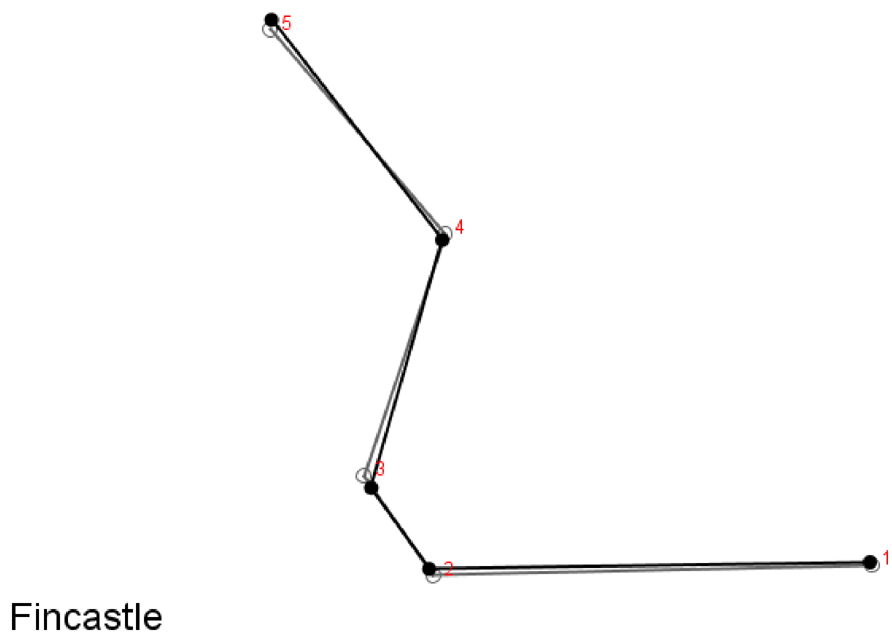


Figure C.46 Shape change between Node 10 (light) and Fincastle (dark).

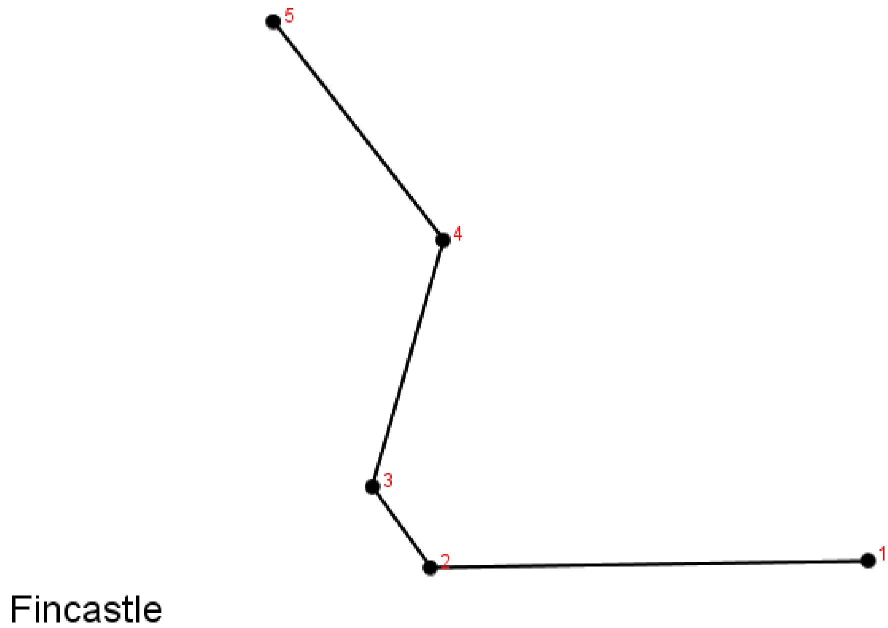


Figure C.47 Average shape for Fincastle.

Appendix D: Results of Arrow vs Dart Metric Testing on Assemblages

List of Tables

Table D.1 Arrow vs Dart Results based on Shott's (1997) Three Variable Equation.

Artifact #	C= Dart	C= Arrow	Result	Values	Assemblage
FaNp-7/3-3	12.6594	13.1504	No Decision	-0.491	Rocky Island
FaNp-7/5-6	15.914	15.459	No Decision	0.455	Rocky Island
EINp-8/17123	20.783	18.9375	Atlatl	1.8455	Fitzgerald
EINp-8/17135	21.841	18.3196	Atlatl	3.5214	Fitzgerald
EINp-8/17155	20.6932	18.6307	Atlatl	2.0625	Fitzgerald
EINp-8/17144	18.114	17.1955	No Decision	0.9185	Fitzgerald
EINp-8/17136	21.4144	19.8009	Atlatl	1.6135	Fitzgerald
EINp-8/17055	27.1248	24.0005	Atlatl	3.1243	Fitzgerald
EINp-8/17156	24.1722	20.967	Atlatl	3.2052	Fitzgerald
EINp-8/17170	21.3942	19.6029	Atlatl	1.7913	Fitzgerald
EINp-8/17079	23.2496	20.4955	Atlatl	2.7541	Fitzgerald
EINp-8/17087	19.1684	17.6011	Atlatl	1.5673	Fitzgerald
EINp-8/17074	19.3054	17.9406	Atlatl	1.3648	Fitzgerald
EINp-8/17080	27.4286	23.3306	Atlatl	4.098	Fitzgerald
EINp-8/17099	23.8636	20.2449	Atlatl	3.6187	Fitzgerald
EINp-8/17104	19.6206	18.5029	Atlatl	1.1177	Fitzgerald
EINp-8/17107	21.26	18.5098	Atlatl	2.7502	Fitzgerald
EINp-8/17108	16.6016	15.8896	No Decision	0.712	Fitzgerald
EINp-8/17110	16.7888	16.6301	No Decision	0.1587	Fitzgerald
EINp-8/17111	21.9498	18.7908	Atlatl	3.159	Fitzgerald
EINp-8/17113	20.1644	18.2001	Atlatl	1.9643	Fitzgerald
EINp-8/17118	28.5758	23.9021	Atlatl	4.6737	Fitzgerald
EINp-8/17120	19.8858	18.5694	Atlatl	1.3164	Fitzgerald

Artifact #	C= Dart	C= Arrow	Result	Values	Assemblage
ElNp-8/17126	20.1086	18.6959	Atlatl	1.4127	Fitzgerald
ElNp-8/17131	15.918	15.0667	No Decision	0.8513	Fitzgerald
ElNp-8/17137	21.9502	19.207	Atlatl	2.7432	Fitzgerald
ElNp-8/17147	21.7376	19.9572	Atlatl	1.7804	Fitzgerald
ElNp-8/17150	15.8672	15.5997	No Decision	0.2675	Fitzgerald
ElNp-8/17151	24.497	20.9026	Atlatl	3.5944	Fitzgerald
ElNp-8/17159	26.7838	23.1637	Atlatl	3.6201	Fitzgerald
ElNp-8/17161	28.627	23.8529	Atlatl	4.7741	Fitzgerald
ElNp-8/17174	19.652	18.6875	No Decision	0.9645	Fitzgerald
ElNp-8/17176	20.3072	18.1312	Atlatl	2.176	Fitzgerald
ElNp-8/17179	15.686	15.3519	No Decision	0.3341	Fitzgerald
ElNp-8/17186	16.0574	15.619	No Decision	0.4384	Fitzgerald
ElNp-8/17194	26.2648	22.085	Atlatl	4.1798	Fitzgerald
DiMv-93/14890	20.9168	18.5214	Atlatl	2.3954	Crane X
DiMv-93/15637	12.205	14.1779	Arrow	-1.9729	Crane X
DiMv-93/10584	18.653	18.8687	No Decision	-0.2157	Crane X
DiMv-93/14726	23.1566	20.792	Atlatl	2.3646	Crane X
DiMv-93/13338	19.001	17.9591	Atlatl	1.0419	Crane X
DiMv-93/15567	17.2848	15.6958	Atlatl	1.589	Crane X
DiMv-93/16586	16.3754	15.1549	Atlatl	1.2205	Crane X
DiMv-93/17077	8.4314	10.2282	Arrow	-1.7968	Crane X
DiMv-93/19492	19.6102	18.3499	Atlatl	1.2603	Crane X
EiNs-4/4562	11.8454	12.6819	No Decision	-0.8365	Bratton
EiNs-4/5259	16.4368	16.4523	No Decision	-0.0155	Bratton

Artifact #	C= Dart	C= Arrow	Result	Values	Assemblage
EiNs-4/6233	12.3654	13.2439	No Decision	-0.8785	Outlook
EiNs-4/6263	12.5368	13.2907	No Decision	-0.7539	Outlook
EiNs-4/6264	12.6842	13.3405	No Decision	-0.6563	Outlook
EiNs-4/6265	17.108	15.7944	Atlatl	1.3136	Outlook
EiNs-4/6790	6.0908	9.1826	Arrow	-3.0918	Outlook
EcNl-1/1C-54	26.6324	23.1357	Atlatl	3.4967	Besant
EcNl-1/1B-220	17.9112	16.6416	Atlatl	1.2696	Besant
EcNl-1/1B-221	23.85	21.4003	Atlatl	2.4497	Besant
EcNl-1/1B-249	16.156	15.3603	No Decision	0.7957	Besant
EcNm-8/2785	24.0856	22.3256	Atlatl	1.76	Walter Felt 13c
EcNm-8/3422	16.1592	16.1032	No Decision	0.056	Walter Felt 13c
EcNm-8/2828	21.0018	18.9806	Atlatl	2.0212	Walter Felt 13c
EcNm-8/3206	14.7934	14.8141	No Decision	-0.0207	Walter Felt 13c
EcNm-8/3371	14.5852	14.7495	No Decision	-0.1643	Walter Felt 13c
EcNm-8/3468	17.1374	16.928	No Decision	0.2094	Walter Felt 13c
EcNm-8/1920	21.8314	20.2116	Atlatl	1.6198	Walter Felt 15a
EcNm-8/2669	19.9442	19.5355	No Decision	0.4087	Walter Felt 15a
EcNm-8/2494	16.0886	17.3024	Arrow	-1.2138	Pelican Lake
EcNm-8/2457	12.9204	14.0167	Arrow	-1.0963	Pelican Lake
EcNm-8/2787	21.2116	21.2596	No Decision	-0.048	Walter Felt 15a
EcNm-8/3207	17.8958	17.4588	No Decision	0.437	Walter Felt 15a
EcNm-8/3314	16.4302	16.111	No Decision	0.3192	Walter Felt 15a
EcNm-8/3315	14.5232	15.2855	No Decision	-0.7623	Walter Felt 15a
EcNm-8/3817	19.0302	18.6846	No Decision	0.3456	Walter Felt 15a

Artifact #	C= Dart	C= Arrow	Result	Values	Assemblage
EcNm-8/3852	8.859	10.0359	Arrow	-1.1769	Walter Felt 15a
EcNm-8/3841	18.1046	18.1228	No Decision	-0.0182	Walter Felt 15a
EcNm-8/3375	22.725	22.187	No Decision	0.538	Pelican Lake
DjPm-116/148560	21.741	19.4071	Atlatl	2.3339	Smyth
DjPm-116/22289	25.0392	21.8072	Atlatl	3.232	Smyth
DjPm-116/22271	28.1832	25.8837	Atlatl	2.2995	Smyth
DjPm-116/102849	13.7058	14.4851	No Decision	-0.7793	Smyth
DjPm-116/102851	18.2102	18.1968	No Decision	0.0134	Smyth
DjPm-116/22257	14.5714	13.8108	No Decision	0.7606	Smyth
DjPm-116/104544	20.917	18.4249	Atlatl	2.4921	Smyth
DjPm-116/102844	14.4946	14.2768	No Decision	0.2178	Smyth
DjPm-116/102806	12.9674	13.3101	No Decision	-0.3427	Smyth
DjPm-116/229144	17.6954	17.7067	No Decision	-0.0113	Smyth
DjPm-116/229182	16.0726	14.8677	Atlatl	1.2049	Smyth
DjPm-116/229192	8.3746	9.6639	Arrow	-1.2893	Smyth
DjPm-116/229164	18.1628	16.8838	Atlatl	1.279	Smyth
DjPm-116/229145	19.562	18.7888	No Decision	0.7732	Smyth
DjPm-116/229147	15.3978	14.3891	Atlatl	1.0087	Smyth
DjPm-116/229199	17.1934	15.9467	Atlatl	1.2467	Smyth
DjPm-116/229215	18.8388	17.637	Atlatl	1.2018	Smyth
DjPm-116/102857	14.6598	13.6777	No Decision	0.9821	Smyth
DjPm-116/229213	18.1514	17.9405	No Decision	0.2109	Smyth
DjPm-116/229168	19.8674	17.8288	Atlatl	2.0386	Smyth
DlOx-5/848	18.396	17.498	No Decision	0.898	Fincastle

Artifact #	C= Dart	C= Arrow	Result	Values	Assemblage
DIOx-5/852	12.03	12.642	No Decision	-0.612	Fincastle
DIOx-5/855	10.824	11.861	Arrow	-1.037	Fincastle
DIOx-5/857	19.4	17.906	Atlatl	1.494	Fincastle
DIOx-5/858	15.43	14.409	Atlatl	1.021	Fincastle
DIOx-5/860	13.504	13.926	No Decision	-0.422	Fincastle
DIOx-5/861	22.272	18.65	Atlatl	3.622	Fincastle
DIOx-5/864	25.574	22.349	Atlatl	3.225	Fincastle
DIOx-5/865	17.832	16.3	Atlatl	1.532	Fincastle
DIOx-5/866	22.874	20.156	Atlatl	2.718	Fincastle
DIOx-5/867	14.82	15.232	No Decision	-0.412	Fincastle
DIOx-5/869	18.104	17.439	No Decision	0.665	Fincastle
DIOx-5/870	14.084	14.512	No Decision	-0.428	Fincastle
DIOx-5/874	29.264	23.753	Atlatl	5.511	Fincastle
DIOx-5/876	28.272	24.068	Atlatl	4.204	Fincastle
DIOx-5/877	24.124	21.436	Atlatl	2.688	Fincastle
DIOx-5/879	25.678	22.868	Atlatl	2.81	Fincastle
DIOx-5/880	21.25	20.322	No Decision	0.928	Fincastle
DIOx-5/881	14.59	15.089	No Decision	-0.499	Fincastle
DIOx-5/882	23.254	20.687	Atlatl	2.567	Fincastle
DIOx-5/883	13.598	14.248	No Decision	-0.65	Fincastle
DIOx-5/884	15.644	14.979	No Decision	0.665	Fincastle
DIOx-5/886	28.244	24.061	Atlatl	4.183	Fincastle
DIOx-5/4004	18.216	16.889	Atlatl	1.327	Fincastle
DIOx-5/4237	30.098	26.639	Atlatl	3.459	Fincastle

Artifact #	C= Dart	C= Arrow	Result	Values	Assemblage
DIOx-5/4506	8.95	9.785	No Decision	-0.835	Fincastle
DIOx-5/4807	16.474	16.31	No Decision	0.164	Fincastle
DIOx-5/4837	26.018	21.854	Atlatl	4.164	Fincastle
DIOx-5/4841	24.976	21.768	Atlatl	3.208	Fincastle
DIOx-5/4976	9.168	11.569	Arrow	-2.401	Fincastle
DIOx-5/5022	20.008	17.921	Atlatl	2.087	Fincastle
DIOx-5/5023	21.904	20.576	Atlatl	1.328	Fincastle
DIOx-5/5104	24.166	22.484	Atlatl	1.682	Fincastle
DIOx-5/5522	19.62	17.511	Atlatl	2.109	Fincastle
DIOx-5/5625	26.096	24.181	Atlatl	1.915	Fincastle
DIOx-5/5822	23.134	20.965	Atlatl	2.169	Fincastle
DIOx-5/5921	12.07	13.083	Arrow	-1.013	Fincastle
DIOx-5/6104	22.568	19.975	Atlatl	2.593	Fincastle
DIOx-5/6704	17.166	17.687	No Decision	-0.521	Fincastle
DIOx-5/7029	20.2576	18.9238	Atlatl	1.3338	Fincastle
DIOx-5/7426	22.142	19.02	Atlatl	3.122	Fincastle

Table D.2 Arrow vs Dart Results based on Shott's (1997) One Variable Equation. (for projectiles lacking any variable but Width)

Artifact #	C= Dart	C= Arrow	Result	Values	Assemblage
EiNs-4/5378	27.9666	20.886	7.0806	Atlatl	Sandy Creek
DgMr-1/4a	11.5	10.8025	0.6975	No Decision	Pelican Lake
DgMr-1/4b	12.172	11.2297	0.9423	No Decision	Pelican Lake
DgMr-1/4c	8.252	8.7377	-0.4857	No Decision	Pelican Lake
DgMr-1/4d	8.014	8.5864	-0.5724	No Decision	Pelican Lake
EcNl-1/4d Pl9-1	7.916	8.5241	-0.6081	No Decision	Sandy Creek
EcNl-1/4d Pl9-2	9.848	9.7523	0.0957	No Decision	Sandy Creek
EcNl-1/4e Pl10-1	4.682	6.4682	-1.7862	Arrow	Sandy Creek
EcNl-1/4e Pl10-2	5.802	7.1802	-1.3782	Arrow	Sandy Creek
EcNl-1/5a Pl11-2	12.018	11.1318	0.8862	No Decision	Pelican Lake
EcNl-1/5a Pl11-3	10.142	9.9392	0.2028	No Decision	Pelican Lake
EcNl-1/4a Pl6-2	10.786	10.3486	0.4374	No Decision	Besant
EcNl-1/4a Pl6-3	10.73	10.313	0.417	No Decision	Besant
EcNl-1/4b Pl7-1	14.132	12.4757	1.6563	Atlatl	Besant
EcNl-1/4b Pl7-2	14.72	12.8495	1.8705	Atlatl	Besant
EcNl-1/4b Pl7-3	13.474	12.0574	1.4166	Atlatl	Besant
DjPm-116/148586	19.914	16.1514	3.7626	Atlatl	Smyth
DjPm-116/148584	10.352	10.0727	0.2793	No Decision	Smyth
DjPm-116/102848	10.044	9.8769	0.1671	No Decision	Smyth
DjPm-116/102804	12.382	11.3632	1.8603	Atlatl	Smyth
DjPm-116/229163	15.84	13.5615	2.2785	Atlatl	Smyth
DjPm-116/229143	5.606	7.0556	-1.4496	Arrow	Smyth

Artifact #	C= Dart	C= Arrow	Result	Values	Assemblage
DjPm-116/229146	10.688	10.2863	0.4017	No Decision	Smyth
DjPm-116/229200	9.036	9.2361	-0.2001	No Decision	Smyth
DjPm-116/229217	12.424	11.3899	1.0341	Atlatl	Smyth
DjPm-116/229214	15.56	13.3835	2.1765	Atlatl	Smyth
DjPm-116/229195	11.71	10.936	0.774	No Decision	Smyth
DjPm-116/229201/202	18.892	15.5017	3.3903	Atlatl	Smyth
DjPm-116/229167	11.822	11.0072	0.8148	No Decision	Smyth
DjPm-116/229166	10.478	10.1528	0.3252	No Decision	Smyth

Table D.3 Projectile Points Lacking Variables Required for any of Shott's (1997) Equations.

Artifact #	Assemblage
ElNp-8/17089	Fitzgerald
ElNp-8/17054	Fitzgerald
ElNp-8/17078	Fitzgerald
DiMv-93/17389	Crane X
EcNl-1/5a Pl11-1	Pelican Lake
DjPm-116/102810	Smyth
DjPm-116/229186	Smyth
DjPm-116/229150	Smyth
DjPm-116/229184	Smyth

Table D.4 Estimated Marginal Means of the Results of Arrow vs Dart Equations.

Dependent Variable	Style	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Test Score	Besant	1.534	.504	.539	2.529
	Bratton	-.426	1.068	-2.537	1.685
	Crane (X)	.578	.534	-.477	1.634
	Fincastle	1.477	.236	1.011	1.943
	Fitzgerald	2.190	.259	1.678	2.702
	Outlook	-.813	.676	-2.148	.522
	Pelican Lake	.116	.478	-.828	1.060
	Rocky Island	-.018	1.068	-2.129	2.093
	Sandy Creek	.716	.676	-.619	2.051
	Smyth	.909	.255	.404	1.413
	Walter Felt (13c)	.644	.617	-.575	1.862
	Walter Felt (15a)	.125	.504	-.870	1.120
Neck Width	Besant	15.801	.608	14.600	17.003
	Bratton	12.965	1.290	10.416	15.514
	Crane (X)	12.820	.645	11.546	14.094
	Fincastle	14.749	.285	14.186	15.312
	Fitzgerald	15.779	.313	15.161	16.397
	Outlook	11.772	.816	10.160	13.384
	Pelican Lake	8.663	.577	7.523	9.803
	Rocky Island	12.235	1.290	9.686	14.784
	Sandy Creek	14.964	.816	13.352	16.576
	Smyth	12.039	.308	11.430	12.648
	Walter Felt (13c)	13.337	.745	11.865	14.808
	Walter Felt (15a)	13.028	.608	11.826	14.229

Table D.5 Estimated Marginal Means of the Results of Arrow vs Dart Equations.

Dependent Variable	Revised Style	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Test Score	Smyth	.909	.258	.399	1.418
	Bratton	.377	.483	-.576	1.331
	Campsite Besant	.772	.283	.212	1.331
	Kill Site Besant	1.800	.176	1.452	2.149
	Outlook	-.586	.577	-1.725	.553
	Pelican Lake	.116	.483	-.837	1.069
Neck Width	Smyth	12.039	.321	11.406	12.672
	Bratton	12.849	.600	11.665	14.033
	Campsite Besant	14.286	.352	13.591	14.982
	Kill Site Besant	15.216	.219	14.784	15.649
	Outlook	11.904	.717	10.489	13.320
	Pelican Lake	8.663	.600	7.479	9.847

Appendix E: Results of the CVA, DFA and Metric Testing on Proposed Cultural Chronology

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Table E.1 Assemblages and Composition.

Groups	Revised Groupings	Observations
1.	Besant	107
2.	Bracken	38
3.	Bratton	12
4.	Outlook	6
5.	Pelican Lake	11

Table E.2 Variation among groups, scaled by the inverse of the within-group variation.

Canonical Variate	Eigenvalues	% Variance	Cumulative %
1.	2.23214881	76.218	76.218
2.	0.45519808	15.543	91.761
3.	0.17931465	6.123	97.884
4.	0.06197292	2.116	100.000

Table E.3 Mahalanobis distances among groups.

Revised Group	Besant	Bracken	Bratton	Outlook	Pelican Lake
Besant	0	2.6445	3.0534	2.5213	4.9252
Bracken	2.6445	0	2.5678	3.6276	2.8738
Bratton	3.0534	2.5678	0	3.0635	3.3366
Outlook	2.5213	3.6267	3.0635	0	4.7320
Pelican Lake	4.9252	2.8738	3.3366	4.7320	0

Table E.4 P-values from permutation tests for Mahalanobis distances among groups.

Revised Group	Besant	Bracken	Bratton	Outlook	Pelican Lake
Besant	1	<.0001	<.0001	<.0001	<.0001
Bracken	<.0001	1	<.0001	<.0001	<.0001
Bratton	<.0001	<.0001	1	0.0001	0.0001
Outlook	<.0001	<.0001	0.0001	1	0.0001
Pelican Lake	<.0001	<.0001	0.0001	0.0001	1

Table E.5 Procrustes distances among groups.

Revised Group	Besant	Bracken	Bratton	Outlook	Pelican Lake
Besant	0	0.1414	0.1956	0.1201	0.2641
Bracken	0.1414	0	0.1829	0.2013	0.1591
Bratton	0.1956	0.1829	0	0.1989	0.2027
Outlook	0.1201	0.2013	0.1989	0	0.2765
Pelican Lake	0.2641	0.1591	0.2027	0.2765	0

Table E.6 P-values from permutation tests for Procrustes distances among groups.

Revised Group	Besant	Bracken	Bratton	Outlook	Pelican Lake
Besant	1	<.0001	<.0001	0.0045	<.0001
Bracken	<.0001	1	<.0001	<.0001	<.0001
Bratton	<.0001	<.0001	1	0.0001	0.0001
Outlook	0.0045	<.0001	0.0001	1	0.0001
Pelican Lake	<.0001	<.0001	0.0001	0.0001	1

Table E.7 Canonical Coefficients.

Landmark Coordinates	CV1	CV2	CV3	CV4
x1	4.7002	6.7539	7.5020	-1.9904
y1	-2.4585	-5.1172	5.9030	-0.2759
x2	-5.1108	1.5929	-10.2718	-2.2535
y2	4.0451	2.7859	2.3555	-9.3545
x3	-1.8570	1.6257	-4.1977	3.2584
y3	-4.8683	13.9379	1.0425	11.6721
x4	-2.9276	-9.7219	3.5750	6.6034
y4	13.7129	-10.2985	-8.7571	0.8006
x5	5.1951	-0.2506	3.3925	-5.6180
y5	-10.4312	-1.3081	-0.5440	-2.8422

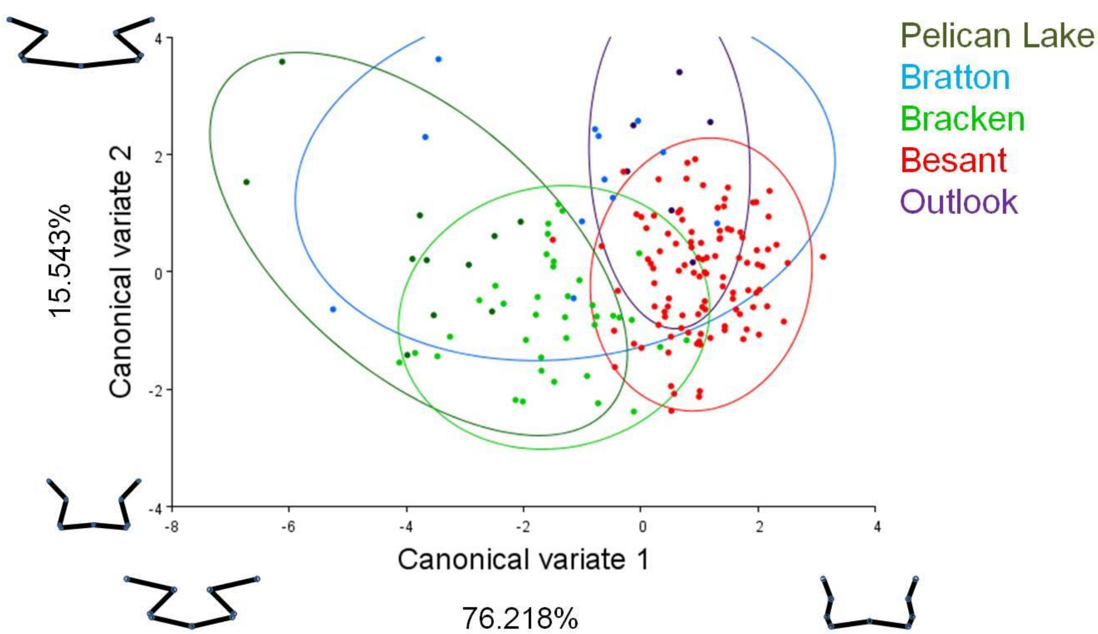


Figure E.1 CVA 1 against CVA 2 with 95% confidence ellipses around group means.

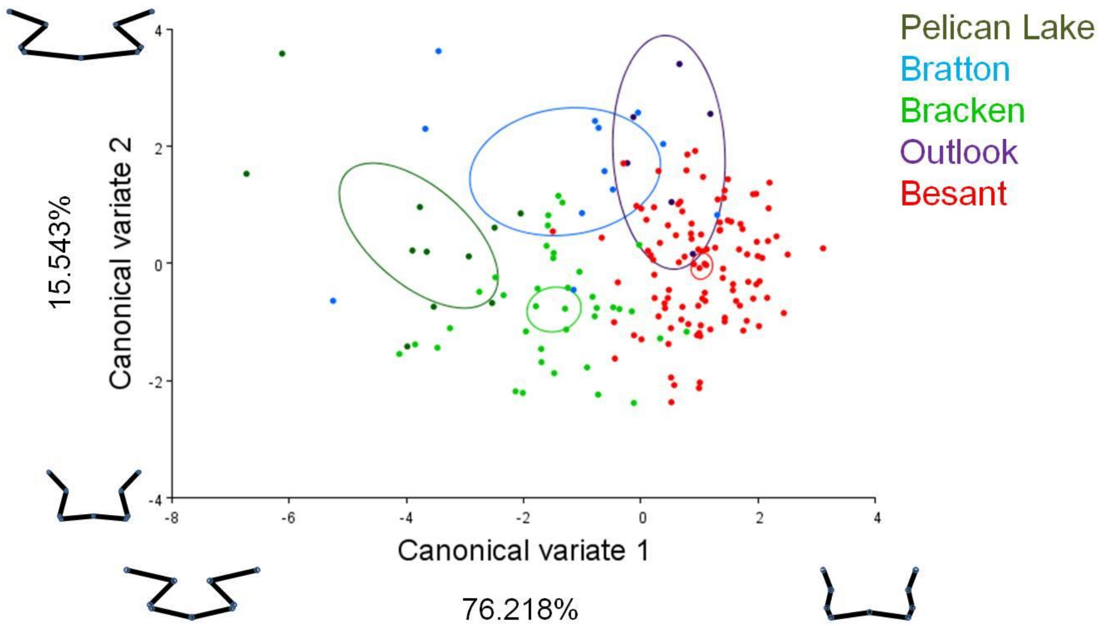


Figure E.2 CVA 1 against CVA 2 with ellipses around group means.

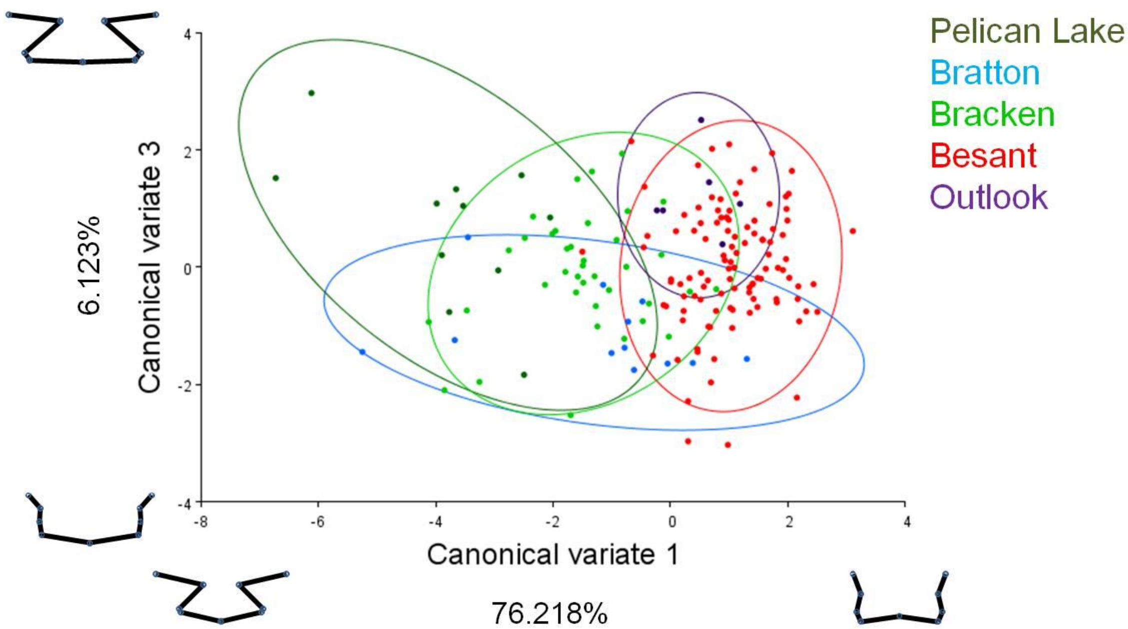


Figure E.3 CVA 1 against CVA 3 with 95% confidence ellipses around group means.

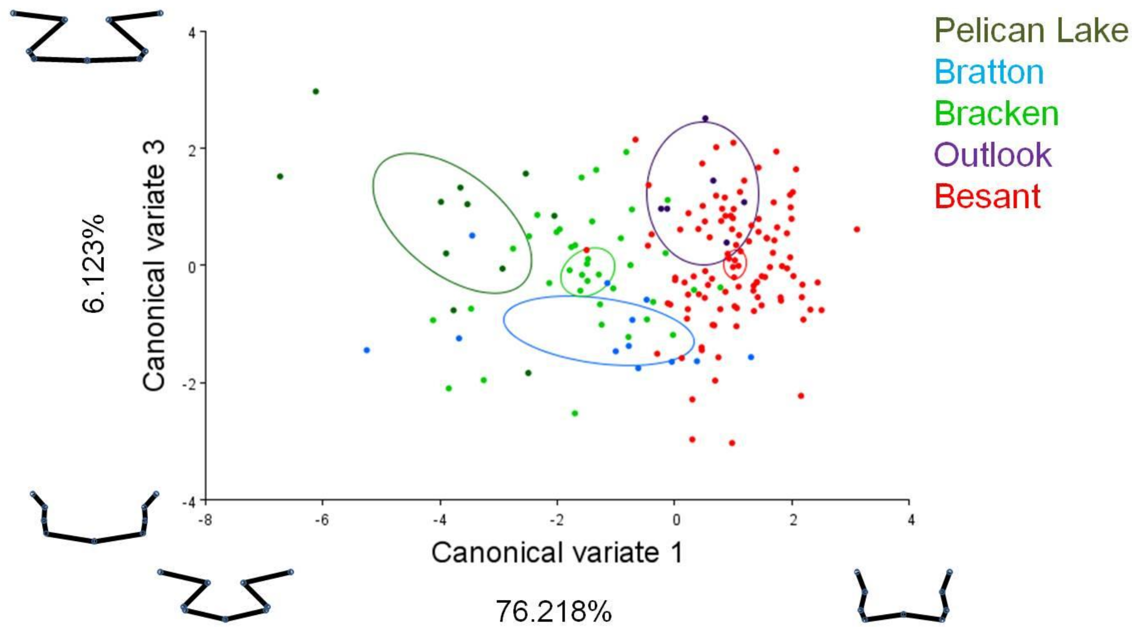


Figure E.4 CVA 1 against CVA 3 with ellipses around group means.

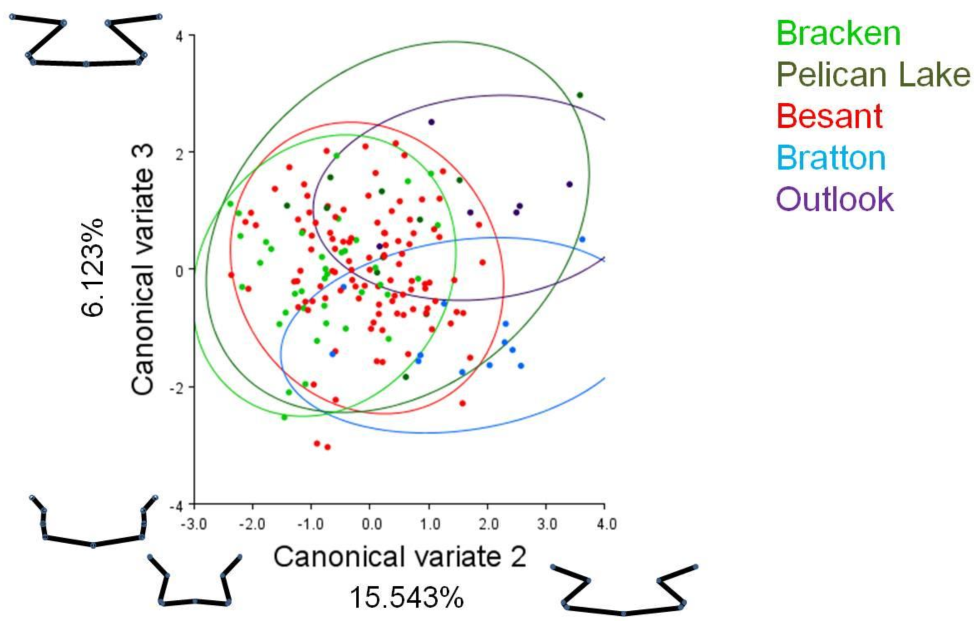


Figure E.5 CVA 2 against CVA 3 with 95% confidence ellipses around group means.

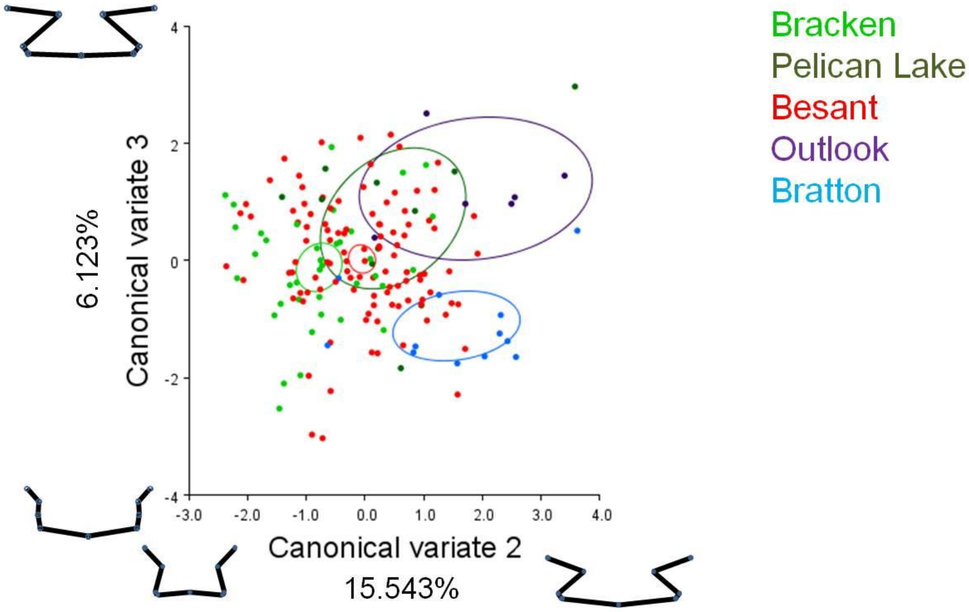


Figure E.6 CVA 2 against CVA 3 with ellipses around group means.

Table E.8 DFA Cross Validation scores (per comparison).

Assemblage	Besant	Bracken	Bratton	Outlook	Pelican Lake
Besant	x	89.3%	89.3%	87.5%	99.5%
Bracken	89.3%	x	89.0%	86.4%	75.2%
Bratton	89.3%	89.0%	X	95.8%	74.2%
Outlook	87.5%	86.4%	95.8%	x	100.0%
Pelican Lake	99.5%	75.2%	74.2%	100.0%	X

Table E.9 DFA Cross Validation scores (per assemblage).

	Besant	Bracken	Bratton	Outlook	Pelican Lake
Total in Assemblage	107	38	12	6	11
DFA vs Besant	x	84.2%	83.3%	83.3%	100.0%
DFA vs Bracken	94.4%	x	83.3%	83.3%	63.6%
DFA vs Bratton	95.3%	94.7%	X	100.0%	81.8%
DFA vs Outlook	91.6%	89.5%	91.7%	x	100.0%
DFA vs Pelican Lake	99.1%	86.8%	66.7%	100.0%	x

Table E.10 Overall Percentages of Correct Classification based on DFA.

Besant	Bracken	Bratton	Outlook	Pelican Lake
91.4%	85.0%	87.1%	92.4%	87.3%

Comparison: Besant -- Bracken

Difference between means:
Procrustes distance: 0.14139935
Mahalanobis distance: 2.9861
T-square: 250.0349, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001

Classification/misclassification tables
Group 1: Besant
Group 2: Bracken

From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	106	1	107
Group 2	3	35	38

From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	101	6	107
Group 2	6	32	38

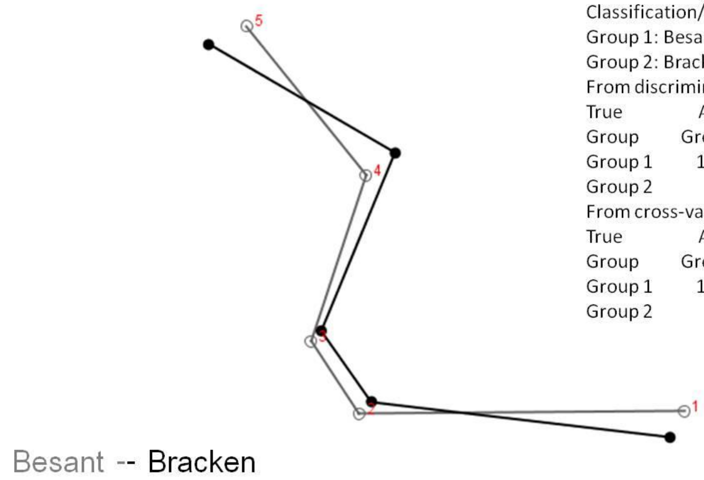


Figure E.7 DFA Results between Besant (light) and Bracken (dark).

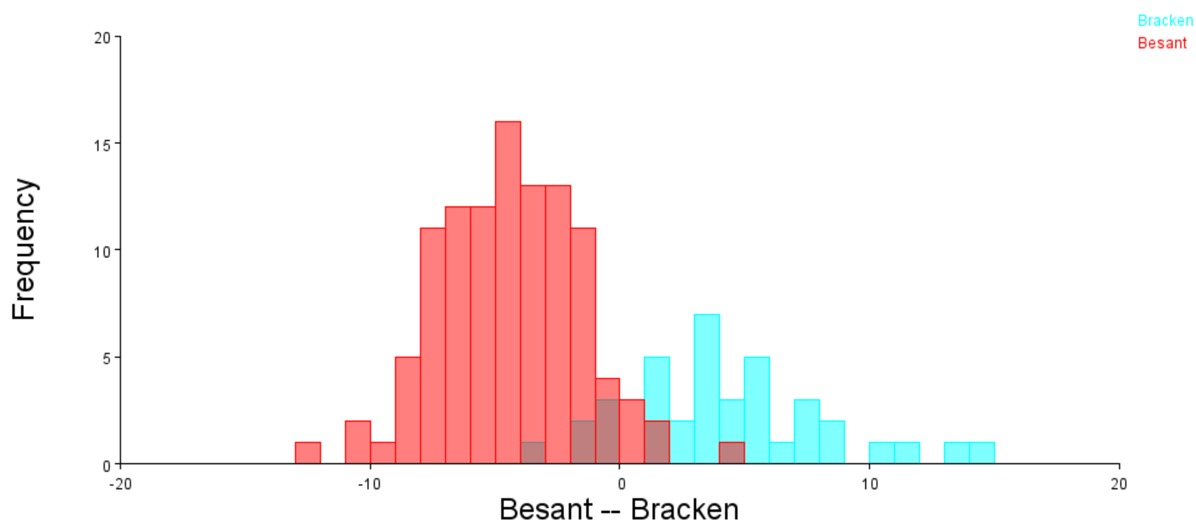


Figure E.8 Histogram of the Cross Validated DFA Results between Besant (red) and Bracken (blue).

Comparison: Besant -- Bratton

Difference between means:
Procrustes distance: 0.19559635
Mahalanobis distance: 3.2697
T-square: 115.3509, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001

Classification/misclassification tables
Group 1: Besant
Group 2: Bratton

From discriminant function:

True Group	Allocated to Group 1	Allocated to Group 2	Total
Group 1	103	4	107
Group 2	1	11	12

From cross-validation:

True Group	Allocated to Group 1	Allocated to Group 2	Total
Group 1	102	5	107
Group 2	2	10	12

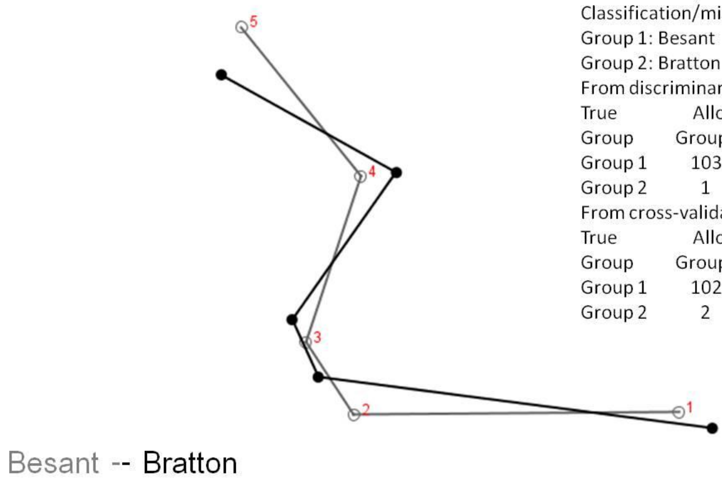


Figure E.9 DFA Results between Besant (light) and Bratton (dark)

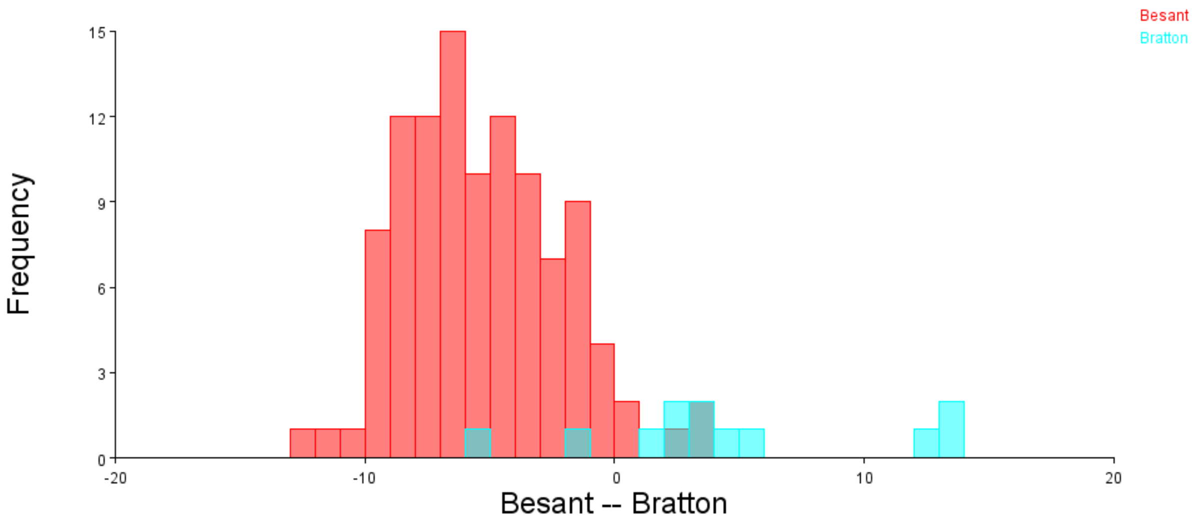


Figure E.10 Histogram of the Cross Validated DFA Results between Besant (red) and Bratton (blue).

Comparison: Besant -- Outlook

Difference between means:
Procrustes distance: 0.12012928
Mahalanobis distance: 2.9382
T-square: 49.0485, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: 0.0020
T-square: <.0001

Classification/misclassification tables
Group 1: Besant
Group 2: Outlook
From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	99	8	107
Group 2	1	5	6

From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	106	1	107
Group 2	1	5	6

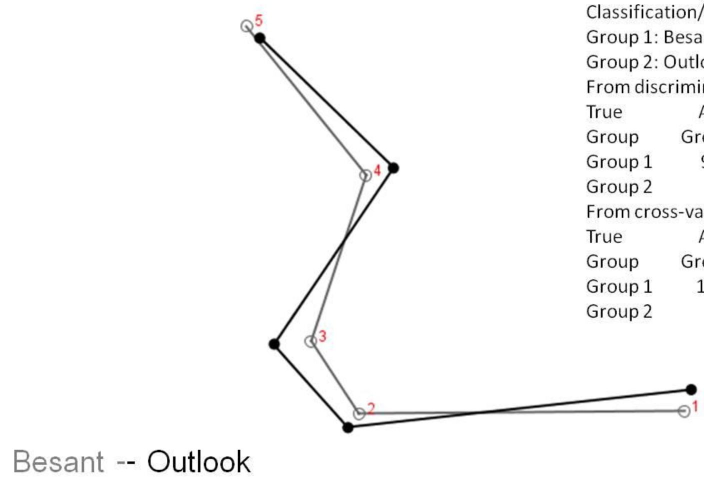


Figure E.11 DFA Results between Besant (light) and Outlook (dark).

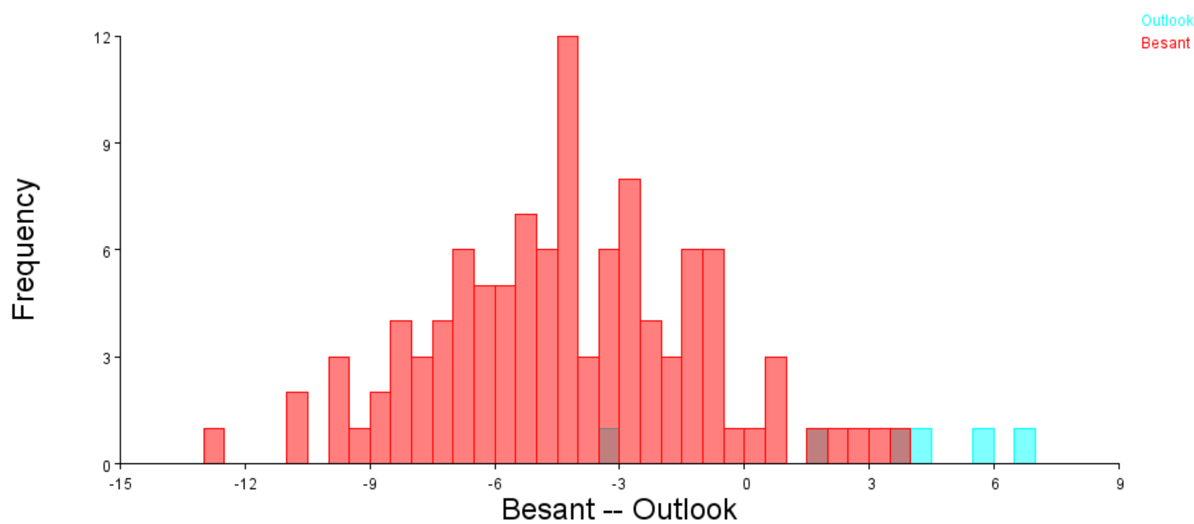
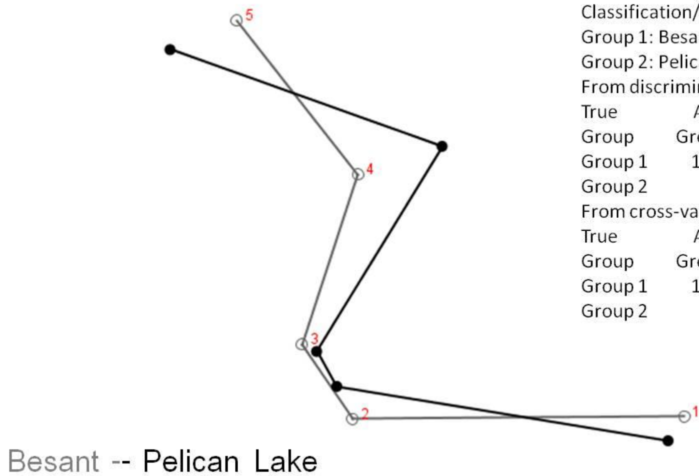


Figure E.12 Histogram of the Cross Validated DFA Results between Besant (red) and Outlook (blue).

Comparison: Besant -- Pelican Lake

Difference between means:
Procrustes distance: 0.26411760
Mahalanobis distance: 5.6703
T-square: 320.7099, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001



Classification/misclassification tables
Group 1: Besant
Group 2: Pelican Lake

From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	106	1	107
Group 2	0	11	11

From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	106	1	107
Group 2	0	11	11

Figure E.13 DFA Results between Besant (light) and Pelican Lake (dark).

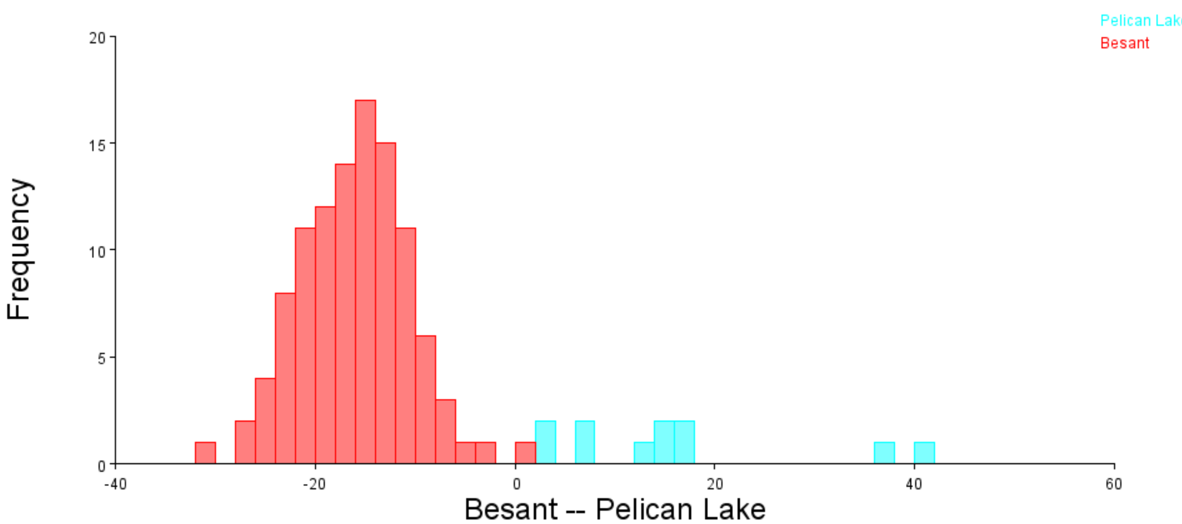


Figure E.14 Histogram of the Cross Validated DFA Results between Besant (red) and Pelican Lake (blue).

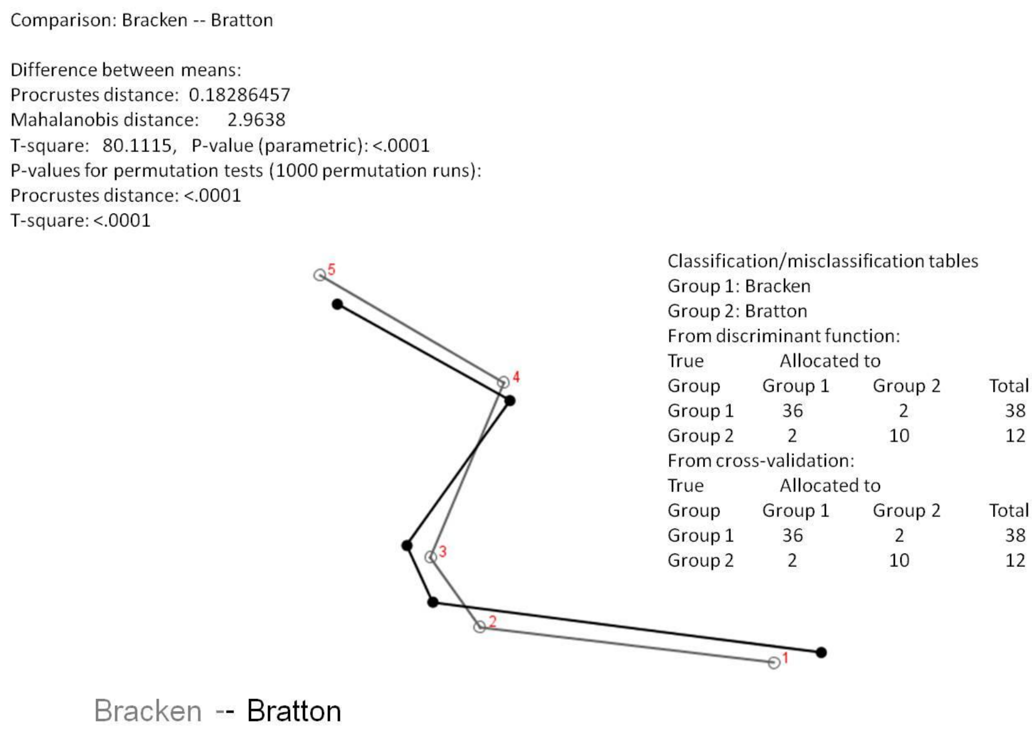


Figure E.15 DFA Results between Bracken (light) and Bratton (dark).

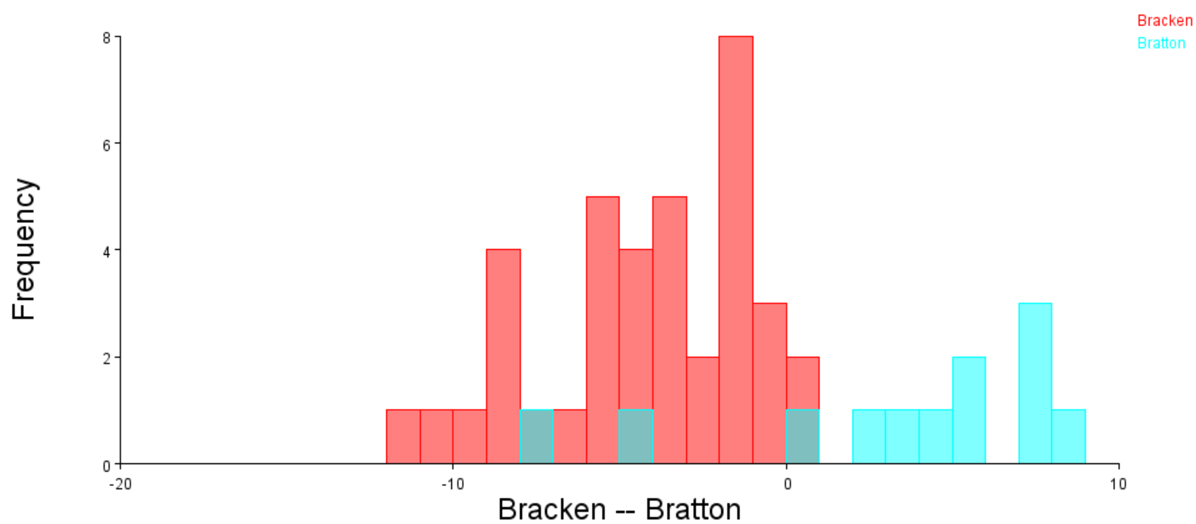
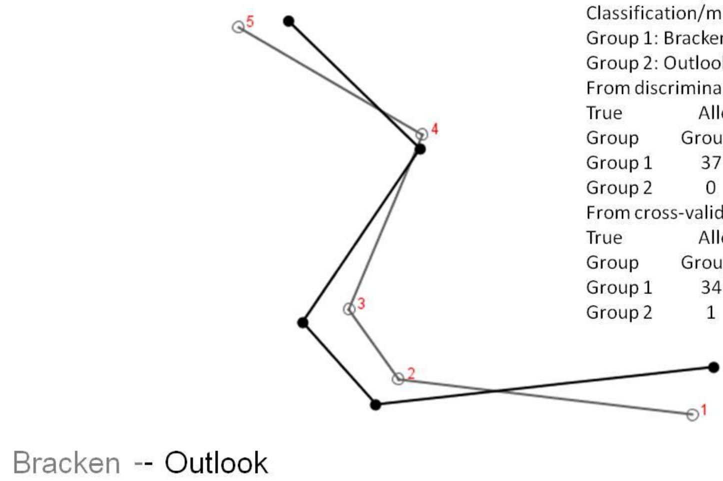


Figure E.16 Histogram of the Cross Validated DFA Results between Bracken (red) and Bratton (blue).

Comparison: Bracken -- Outlook

Difference between means:
Procrustes distance: 0.20128415
Mahalanobis distance: 3.6149
T-square: 67.7130, P-value (parametric): <.0001
P-values for permutation tests (1000 permutation runs):
Procrustes distance: <.0001
T-square: <.0001



Classification/misclassification tables
Group 1: Bracken
Group 2: Outlook

From discriminant function:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	37	1	38
Group 2	0	6	6

From cross-validation:

True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	34	4	38
Group 2	1	5	6

Figure E.17 DFA Results between Bracken (light) and Outlook (dark).

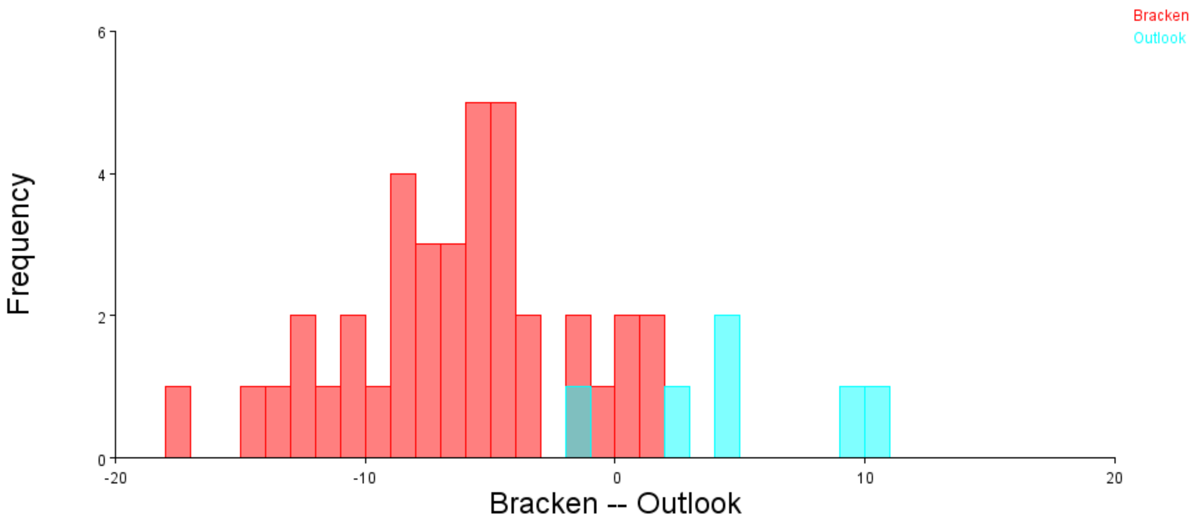


Figure E.18 Histogram of the Cross Validated DFA Results between Bracken (red) and Outlook (blue).

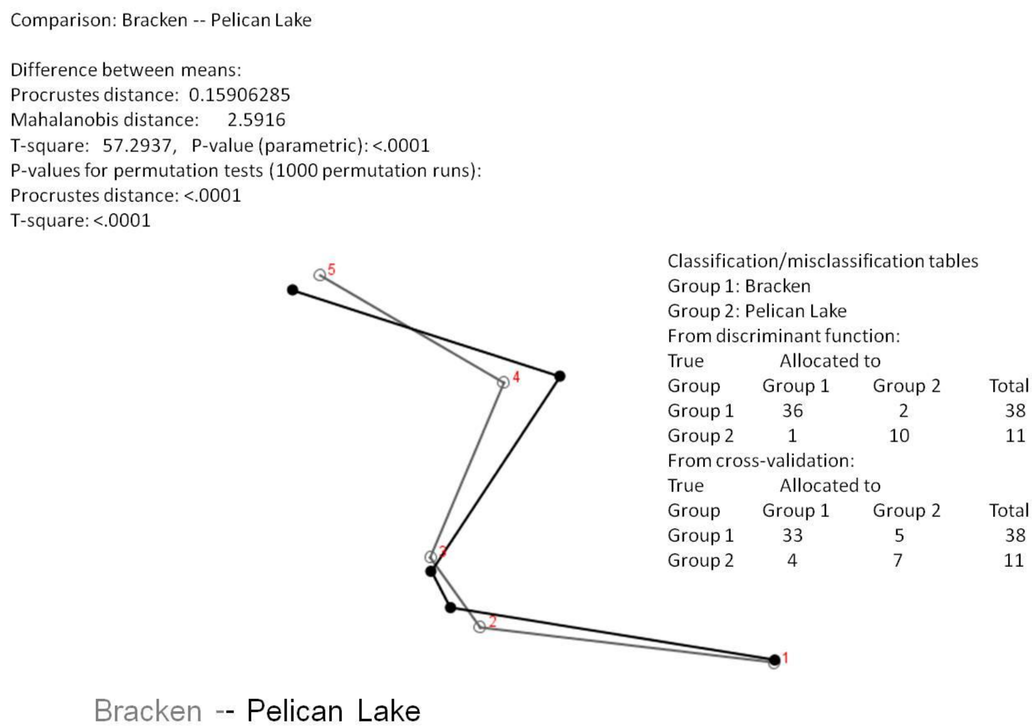


Figure E.19 DFA Results between Bracken (light) and Pelican Lake (dark).

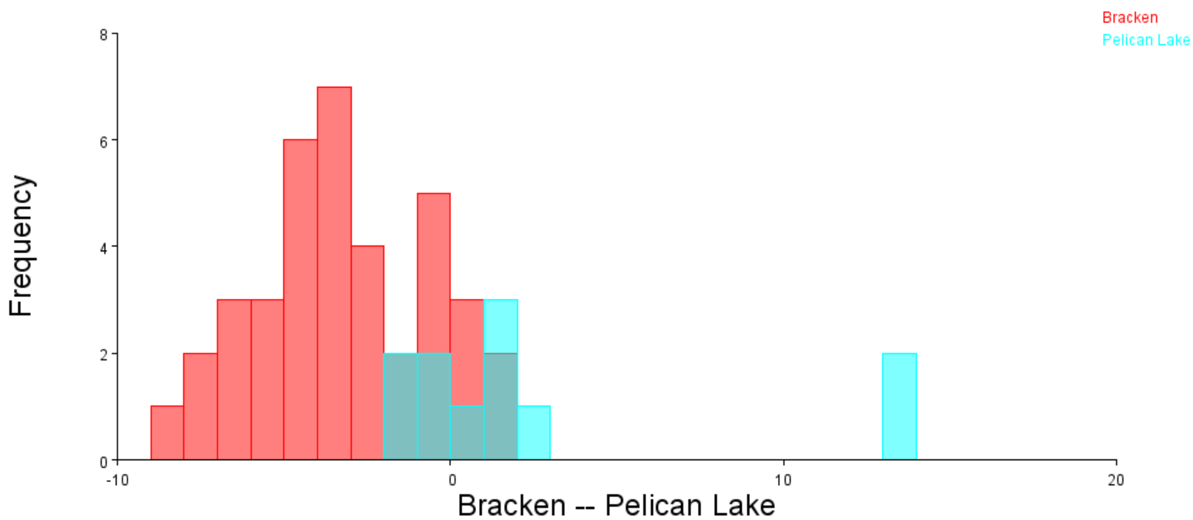


Figure E.20 Histogram of the Cross Validated DFA Results between Bracken (red) and Pelican Lake (blue).

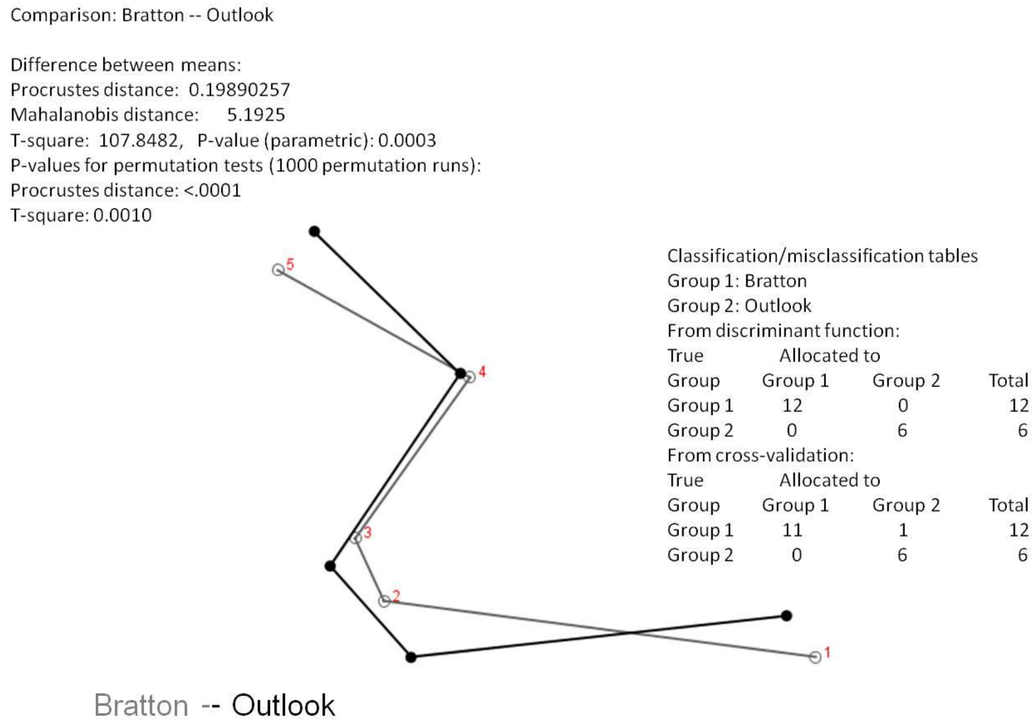


Figure E.21 DFA Results between Bratton (light) and Outlook (dark).

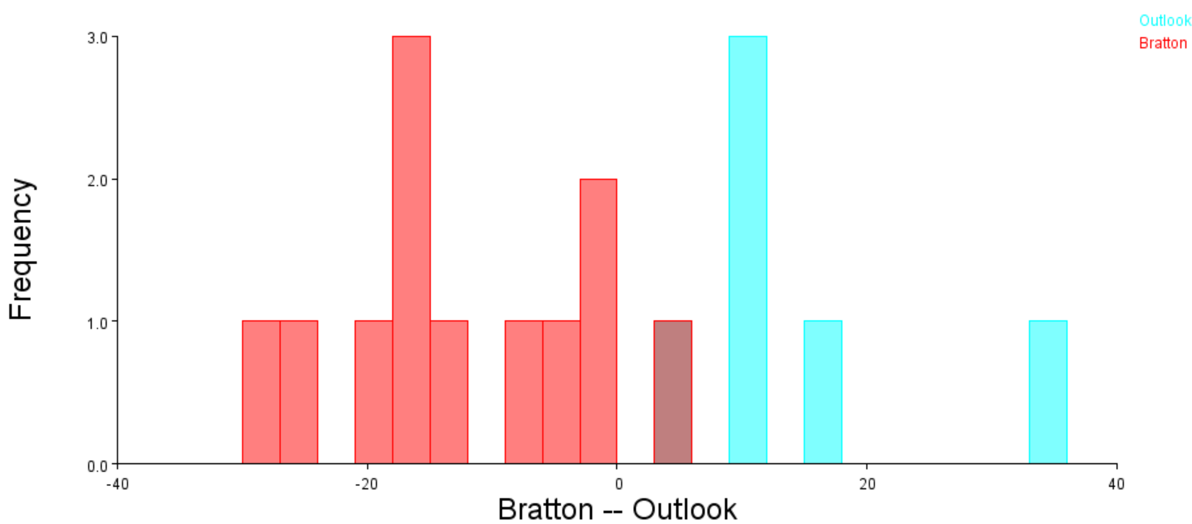


Figure E.22 Histogram of the Cross Validated DFA Results between Bratton (R) and Outlook (B).

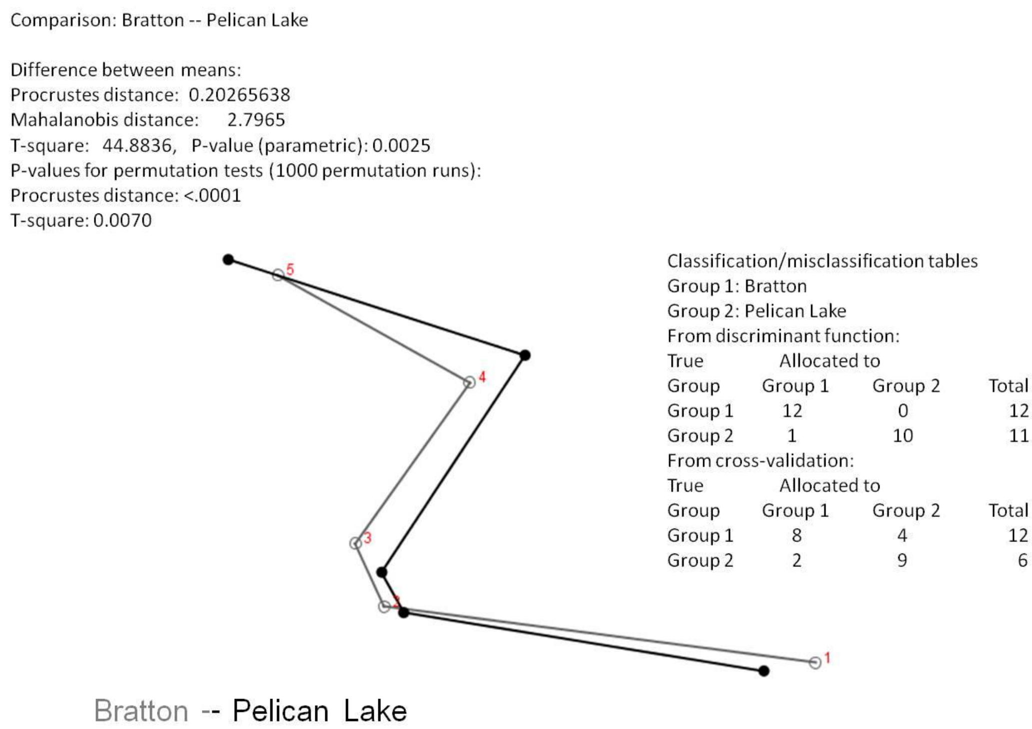


Figure E.23 DFA Results between Bratton (light) and Pelican Lake (dark).

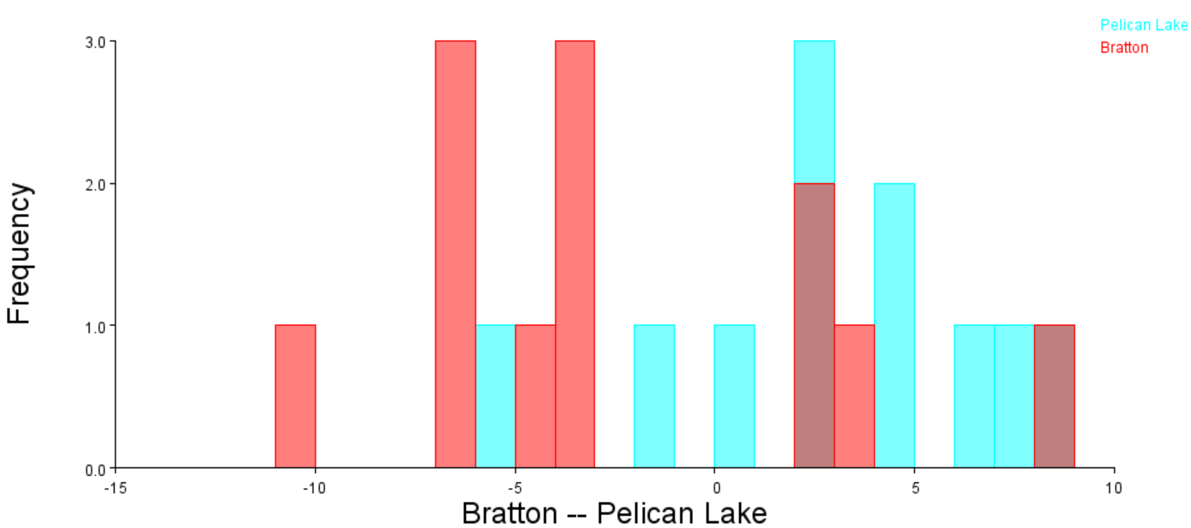


Figure E.24 Histogram of the Cross Validated DFA Results between Bratton (R) and Pelican Lake (B).

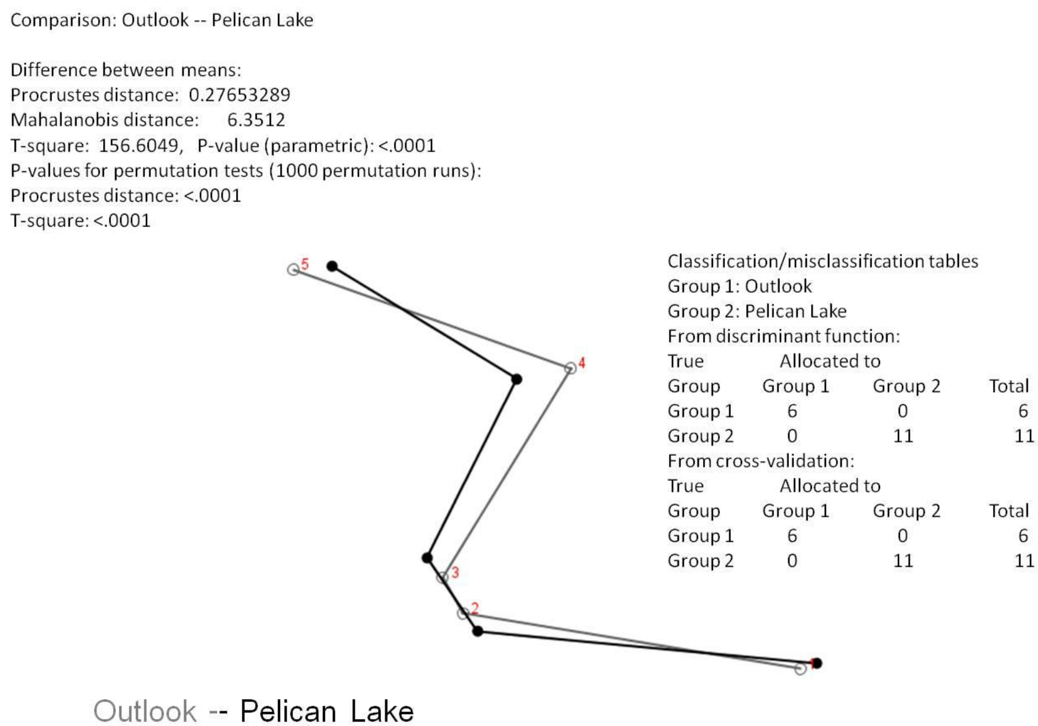


Figure E.25 DFA Results between Outlook (light) and Pelican Lake (dark).

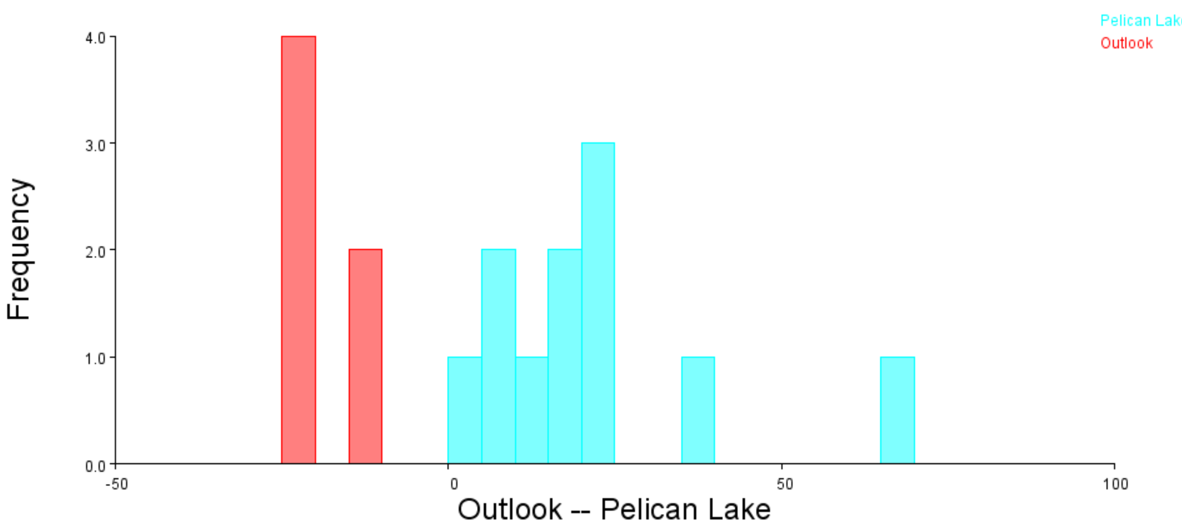


Figure E.26 Histogram of the Cross Validated DFA Results between Outlook (R) and Pelican Lake (B).

Table E.11 Estimated Marginal Means of the Results of Arrow vs Dart Equations.

Dependent Variable	Proposed Style	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
C Test Score	Besant	1.514	.155	1.207	1.820
	Bracken	.909	.267	.381	1.437
	Bratton	.298	.477	-.643	1.240
	Outlook	-.602	.646	-1.877	.673
	Pelican Lake	-.333	.457	-1.234	.569
Neck Width	Besant	14.957	.188	14.586	15.328
	Bracken	12.039	.324	11.400	12.678
	Bratton	12.778	.577	11.638	13.918
	Outlook	11.877	.782	10.333	13.420
	Pelican Lake	8.413	.553	7.322	9.505

Appendix F: Arrow vs Dart Equations Preliminary Testing Results

List of Tables

Table F.1 Northern Plains Projectile Point Test Group.

Artifact #	Length	Width	Thick	Neck	Notes
2/33 1E-668	42.2	24.74	7.03	16.27	Early Side-Notch
2/38 1E-693	47.81	24.46	7.12	15.62	Early Side-Notch
2/40 1E-675	41.15	24.65	6.56	17.46	Early Side-Notch
1/1813 1E-856	42.09	24.44	6.46	15.15	Early Side-Notch
10X347	41.09	24.76	6.57	14.43	Early Side-Notch
102486	28.31	20.43	7.61	15.95	Early Side-Notch
X	27.71	19.61	5.39	14.21	Early Side-Notch
102330	48.88	21.96	5.21	17.67	Oxbow
10X325	40.39	24.82	6.07	17.1	Oxbow
102670	28.7	20.85	5.19	17.71	Oxbow
107189	29.28	20.21	6.61	17.94	Oxbow
108590	28.25	20.48	6.37	16.21	Oxbow
102751	29.09	15.01	4.36	14.54	McKean
104321	28.71	19.64	5.64	18.57	McKean
105804	26.88	17.74	5.8	17.74	McKean
108870	31.36	16.77	5.3	15.28	McKean
106963	56.82	20.22	8.55	15.48	Duncan
X00527	37.62	20.6	6.56	16.1	Hanna
106837	28.26	17.51	6.34	11.45	Hanna
107191	30.77	17.11	7.56	12.77	Hanna
102804	16.76	12.02	2.74	9.95	Avonlea
103112	20.38	12.62	3.85	9.39	Avonlea
X0118XX2	19.61	14.04	2.87	10.48	Avonlea

Artifact #	Length	Width	Thick	Neck	Notes
145 V	20.12	14.06	2.72	10.45	Avonlea
1/1829 1E-872	19.15	14.06	3.99	8.65	Prairie Side-Notched
102084	29.42	13.88	4.57	10.61	Prairie Side-Notched
102745	22.35	14.26	3.62	9.86	Prairie Side-Notched
1030X2	22.17	15.49	4.29	10.45	Prairie Side-Notched
103145	18.3	13.18	4.02	9.73	Prairie Side-Notched
1071X0	19.93	16.3	4.92	12.7	Prairie Side-Notched
102XXX	21.04	16.24	4.07	11.99	Prairie Side-Notched
X	27.52	16.04	4.61	11.79	Prairie Side-Notched
2/10 1E-654	16.84	12.91	3.21	8.05	Plains Side-Notched
2/19 1E-654	26.22	14.26	4.64	10.41	Plains Side-Notched
2/20 1E-655	22.99	13.31	4.1	8.48	Plains Side-Notched
102099	17.34	13.74	3.14	11.67	Plains Side-Notched
102265	22.5	14.74	3.01	8.83	Plains Side-Notched
106134	17.35	13.56	2.77	9.99	Plains Side-Notched
108923	21.17	13.31	4.01	8.41	Plains Side-Notched
X	19.02	13.29	3.69	9.86	Plains Side-Notched

Metrics for projectile points used to test classification

Table F.2 Short list of results of the testing of the Dart/Arrow Equations.

Thomas	Shott 3	Shott 1	K & K	K & K 1	Bradbury	H & K
Atlatl	Atlatl	Atlatl	Atlatl	Atlatl	Atlatl	Atlatl
Atlatl	Atlatl	Atlatl	Atlatl	Atlatl	Atlatl	Atlatl
Atlatl	Atlatl	Atlatl	Atlatl	Atlatl	Atlatl	Atlatl
Arrow	Atlatl	No Decision	Atlatl	Atlatl	No Decision	Atlatl
Arrow	No Decision	No Decision	Atlatl	Atlatl	No Decision	Atlatl
No Decision	Atlatl	Atlatl	Atlatl	Atlatl	No Decision	Atlatl
Atlatl	Atlatl	Atlatl	Atlatl	Atlatl	Atlatl	Atlatl
Arrow	Atlatl	Atlatl	Atlatl	Atlatl	Arrow	Atlatl
Arrow	Atlatl	No Decision	Atlatl	Atlatl	Arrow	Atlatl
Arrow	Atlatl	No Decision	Atlatl	Atlatl	No Decision	Atlatl
Arrow	Arrow	Arrow	No Decision	Atlatl	Arrow	Atlatl
Arrow	Atlatl	No Decision	Atlatl	Atlatl	Arrow	Atlatl
Arrow	No Decision	No Decision	Atlatl	Atlatl	Arrow	Atlatl
Arrow	No Decision	Arrow	Atlatl	Atlatl	Arrow	Atlatl
Arrow	Atlatl	No Decision	Atlatl	Atlatl	No Decision	Atlatl
Arrow	Atlatl	No Decision	Atlatl	Atlatl	No Decision	Atlatl
Arrow	No Decision	No Decision	Atlatl	Atlatl	No Decision	Atlatl
Arrow	No Decision	No Decision	Atlatl	Atlatl	Arrow	Atlatl
Arrow	Arrow	Arrow	Arrow	Arrow	Arrow	Atlatl
Arrow	Arrow	Arrow	Arrow	Arrow	Arrow	Atlatl
Arrow	Arrow	Arrow	Arrow	No Decision	Arrow	Atlatl
Arrow	Arrow	Arrow	Arrow	No Decision	Arrow	Atlatl
Arrow	Arrow	Arrow	Arrow	Arrow	Arrow	Atlatl

Thomas	Shott 3	Shott 1	K & K	K & K 1	Bradbury	H & K
Arrow	Arrow	Arrow	Arrow	No Decision	Arrow	Atlatl
Arrow	Arrow	Arrow	Arrow	Arrow	Arrow	Atlatl
Arrow	Arrow	Arrow	Arrow	No Decision	Arrow	Atlatl
Arrow	Arrow	Arrow	Arrow	Arrow	Arrow	Atlatl
Arrow	Arrow	Arrow	Atlatl	Atlatl	Arrow	Atlatl
Arrow	Arrow	Arrow	No Decision	Atlatl	Arrow	Atlatl
Arrow	Arrow	Arrow	No Decision	Atlatl	Arrow	Atlatl
Arrow	Arrow	Arrow	Arrow	Arrow	Arrow	Arrow
Arrow	Arrow	Arrow	Arrow	No Decision	Arrow	Atlatl
Arrow	Arrow	Arrow	Arrow	Arrow	Arrow	Atlatl
Arrow	Arrow	Arrow	Arrow	Atlatl	Arrow	Atlatl
Arrow	Arrow	Arrow	Arrow	Arrow	Arrow	No Decision
Arrow	Arrow	Arrow	Arrow	Arrow	Arrow	Atlatl
Arrow	Arrow	Arrow	Arrow	Arrow	Arrow	Atlatl
Arrow	Arrow	Arrow	Arrow	Arrow	Arrow	Atlatl

Green Indicates correct assignment, red indicates incorrect assignment, orange indicates "no decision" which is equal to an answer of less than 1 between the difference between C=arrow and C=dart, or within .5 of the index value.

A negative (-) value denotes an "Arrow" and an answer between 1 and -1 would denote a "No Decision"

Table F.3 Thomas (1978).

Artifact #	C Dart (Cd)	C Arrow (Ca)	Cd - Ca
2/33 1E-668	19.32085	17.8191	1.50175
2/38 1E-693	20.21836	18.23204	1.98632
2/40 1E-675	18.56539	17.51198	1.05341
1/1813 1E-856	18.96499	16.93406	2.03093
10X347	19.36627	16.91742	2.44885
102486	11.8147	14.72592	-2.91122
X	10.23158	11.98528	-1.7537
102330	16.20115	15.96106	0.24009
10X325	18.51556	17.0094	1.50616
102670	11.053	13.2512	-2.1982
107189	10.89619	14.28914	-3.39295
108590	11.31961	13.72722	-2.40761
102751	4.47067	9.15302	-4.68235
104321	9.58145	13.25642	-3.67497
105804	7.19572	12.1264	-4.93068
108870	7.22169	11.1959	-3.97421
106963	17.39482	18.41788	-1.02306
X00527	13.32478	14.9362	-1.61142
106837	8.79236	11.28784	-2.49548
107191	8.96612	12.70748	-3.74136
102804	-1.06179	4.03414	-5.09593

Artifact #	C Dart (Cd)	C Arrow (Ca)	Cd - Ca
103112	0.90177	5.5463	-4.64453
X0118XX2	1.84088	5.51708	-3.6762
145 V	1.90875	5.44554	-3.53679
1/1829 1E-872	2.62563	6.05286	-3.42723
102084	4.12977	7.99798	-3.86821
102745	3.05336	6.43172	-3.37836
1030X2	4.63274	7.69552	-3.06278
103145	1.17635	5.8045	-4.62815
1071X0	4.93288	8.86012	-3.92724
102XXX	4.89439	8.06546	-3.17107
X	6.12791	9.09506	-2.96715
2/10 1E-654	0.63364	4.46056	-3.82692
2/19 1E-654	4.05811	7.84866	-3.79055
2/20 1E-655	2.52483	6.17374	-3.64891
102099	0.89309	5.61886	-4.72577
102265	3.65053	5.92606	-2.27553
106134	0.90767	4.85614	-3.94847
108923	2.163	5.88444	-3.72144
X	1.28591	5.67666	-4.39075

Table F.4 Shott Three Variate (1997).

Artifact #	C Dart (Cd)	C Arrow (Ca)	Cd - Ca
2/33 1E-668	27.9984	23.9734	4.025
2/38 1E-693	27.5788	23.8412	3.7376
2/40 1E-675	27.4272	23.1739	4.2533
1/1813 1E-856	26.095	22.3851	3.7099
10X347	26.4316	22.6946	3.737
102486	23.6576	22.1277	1.5299
X	17.6728	16.6803	0.9925
102330	21.5524	18.5902	2.9622
10X325	26.5506	22.2183	4.3323
102670	20.1524	17.7909	2.3615
107189	22.201	20.304	1.897
108590	21.4128	19.6696	1.7432
102751	10.096	11.4575	-1.3615
104321	19.8518	18.0419	1.8099
105804	17.4908	16.9012	0.5896
108870	14.3832	14.7395	-0.3563
106963	25.0422	23.8205	1.2217
X00527	21.8884	20.121	1.7674
106837	15.863	16.6544	-0.7914
107191	18.2354	19.1302	-0.8948
102804	1.5014	5.2013	-3.6999
103112	4.186	7.7844	-3.5984
X0118XX2	4.4598	6.9623	-2.5025

Artifact #	C Dart (Cd)	C Arrow (Ca)	Cd - Ca
145 V	4.1822	6.6629	-2.4807
1/1829 1E-872	5.962	8.9244	-2.9624
102084	7.6088	10.3616	-2.7528
102745	5.952	8.5338	-2.5818
1030X2	9.0012	10.8681	-1.8669
103145	5.3394	8.5839	-3.2445
1071X0	12.0828	13.146	-1.0632
102XXX	10.0896	11.2272	-1.1376
X	10.8132	12.1582	-1.345
2/10 1E-654	2.7948	6.4179	-3.6231
2/19 1E-654	8.1398	10.7293	-2.5895
2/20 1E-655	5.1808	8.6001	-3.4193
102099	5.0638	7.5349	-2.4711
102265	4.9724	7.4188	-2.4464
106134	3.4844	6.333	-2.8486
108923	4.9796	8.4023	-3.4227
X	4.885	8.008	-3.123

Table F.5 Shott One Variate (1997).

Artifact #	C Dart (Cd)	C Arrow (Ca)	Cd – Ca
2/33 1E-668	17.786	14.7986	2.9874
2/38 1E-693	17.394	14.5494	2.8446
2/40 1E-675	17.66	14.7185	2.9415
1/1813 1E-856	17.366	14.5316	2.8344
10X347	17.814	14.8164	2.9976
102486	11.752	10.9627	0.7893
X	10.604	10.2329	0.3711
102330	13.894	12.3244	1.5696
10X325	17.898	14.8698	3.0282
102670	12.34	11.3365	1.0035
107189	11.444	10.7669	0.6771
108590	11.822	11.0072	0.8148
102751	4.164	6.1389	-1.9749
104321	10.646	10.2596	0.3864
105804	7.986	8.5686	-0.5826
108870	6.628	7.7053	-1.0773
106963	11.458	10.7758	0.6822
X00527	11.99	11.114	0.876
106837	7.664	8.3639	-0.6999
107191	7.104	8.0079	-0.9039
102804	-0.022	3.4778	-3.4998
103112	0.818	4.0118	-3.1938
X0118XX2	2.806	5.2756	-2.4696

Artifact #	C Dart (Cd)	C Arrow (Ca)	Cd - Ca
145 V	2.834	5.2934	-2.4594
1/1829 1E-872	2.834	5.2934	-2.4594
102084	2.582	5.1332	-2.5512
102745	3.114	5.4714	-2.3574
1030X2	4.836	6.5661	-1.7301
103145	1.602	4.5102	-2.9082
1071X0	5.97	7.287	-1.317
102XXX	5.886	7.2336	-1.3476
X	5.606	7.0556	-1.4496
2/10 1E-654	1.224	4.2699	-3.0459
2/19 1E-654	3.114	5.4714	-2.3574
2/20 1E-655	1.784	4.6259	-2.8419
102099	2.386	5.0086	-2.6226
102265	3.786	5.8986	-2.1126
106134	2.134	4.8484	-2.7144
108923	1.784	4.6259	-2.8419
X	1.756	4.6081	-2.8521

Table F.6 Knight and Keyser (1983).

Artifact #	C Dart (Cd)	C Arrow (Ca)	Cd - Ca
2/33 1E-668	101.411234	82.826615	18.58462
2/38 1E-693	100.568821	81.892719	18.6761
2/40 1E-675	100.019951	82.48115	17.5388
1/1813 1E-856	92.933585	76.978235	15.95535
10X347	92.694439	76.56264	16.1318
102486	93.781197	77.651551	16.12965
X	68.193837	60.732411	7.461426
102330	83.495826	71.778175	11.71765
10X325	95.182705	79.314186	15.86852
102670	78.356208	68.769442	9.586766
107189	89.77325	75.966362	13.80689
108590	83.833811	71.521316	12.3125
102751	49.471057	48.597072	0.873985
104321	81.573795	71.038299	10.5355
105804	76.163392	67.10025	9.063142
108870	63.883472	58.130121	5.753351
106963	103.690884	83.194501	20.49638
X00527	86.620178	73.087154	13.53302
106837	64.54779	56.997525	7.550265
107191	77.793029	65.81593	11.9771
102804	15.326332	25.006144	-9.67981
103112	25.354408	31.068427	-5.71402
X0118XX2	22.890499	30.162602	-7.2721

Artifact #	C Dart (Cd)	C Arrow (Ca)	Cd - Ca
145 V	21.627544	29.349862	-7.72232
1/1829 1E-872	27.931513	32.53747	-4.60596
102084	38.72704	39.996781	-1.26974
102745	28.654607	33.492583	-4.83798
1030X2	38.809103	40.266667	-1.45756
103145	28.74803	33.443158	-4.69513
1071X0	51.577369	49.398663	2.178706
102XXX	42.430342	43.315653	-0.88531
X	46.908834	45.917139	0.991695
2/10 1E-654	16.68639	25.12205	-8.43565
2/19 1E-654	39.33087	40.3804	-1.04952
2/20 1E-655	27.15453	31.83296	-4.67843
102099	27.25121	33.42841	-6.17721
102265	21.92607	28.86222	-6.93616
106134	19.38247	27.72813	-8.34565
108923	25.97827	31.09223	-5.11396
X	26.57164	32.13289	-5.56125

Table F.7 Knight and Keyser One Variate (1983).

Artifact #	C Dart (Cd)	C Arrow (Ca)	Cd - Ca
2/33 1E-668	44.65927	36.80975	7.84952
2/38 1E-693	41.62962	34.7265	6.90312
2/40 1E-675	50.20586	40.6237	9.58216
1/1813 1E-856	39.43895	33.22015	6.2188
10X347	36.08303	30.91255	5.17048
102486	43.16775	35.78415	7.3836
X	35.05761	30.20745	4.85016
102330	51.18467	41.29675	9.88792
10X325	48.5279	39.4699	9.058
102670	51.37111	41.42495	9.94616
107189	52.44314	42.1621	10.28104
108590	44.37961	36.61745	7.76216
102751	36.59574	31.2651	5.33064
104321	55.37957	44.18125	11.19832
105804	51.51094	41.5211	9.98984
108870	40.04488	33.6368	6.40808
106963	40.97708	34.2778	6.69928
X00527	43.8669	36.2649	7.602
106837	22.19325	21.36165	0.8316
107191	28.34577	25.59225	2.75352
102804	15.20175	16.55415	-1.3524
103112	12.59159	14.75935	-2.16776
X0118XX2	17.67208	18.2528	-0.58072

Artifact #	C Dart (Cd)	C Arrow (Ca)	Cd - Ca
145 V	17.53225	18.15665	-0.6244
1/1829 1E-872	9.14245	12.38765	-3.2452
102084	18.27801	18.66945	-0.39144
102745	14.78226	16.2657	-1.48344
1030X2	17.53225	18.15665	-0.6244
103145	14.17633	15.84905	-1.67272
1071X0	28.0195	25.3679	2.6516
102XXX	24.71019	23.09235	1.61784
X	23.77799	22.45135	1.32664
2/10 1E-654	6.34585	10.46465	-4.1188
2/19 1E-654	17.34581	18.02845	-0.68264
2/20 1E-655	8.35008	11.8428	-3.49272
102099	23.21867	22.06675	1.15192
102265	9.98143	12.96455	-2.98312
106134	15.38819	16.68235	-1.29416
108923	8.02381	11.61845	-3.59464
X	14.78226	16.2657	-1.48344

Table F.8 Bradbury (1997).

Artifact #	C Dart (Cd)	C Arrow (Ca)	Cd - Ca
2/33 1E-668	18.7135937	16.03954284	2.674051
2/38 1E-693	18.280671	15.53218346	2.748488
2/40 1E-675	18.6499565	16.58749954	2.062457
1/1813 1E-856	18.2268829	15.28065392	2.946229
10X347	18.6426842	15.1169636	3.525721
102486	12.5725078	13.15263008	-0.58012
X	11.3134926	11.74993068	-0.43644
102330	14.8392384	14.99394097	-0.1547
10X325	18.8720655	16.51197518	2.36009
102670	13.2642675	14.31266283	-1.0484
107189	12.367347	14.02503411	-1.65769
108590	12.6575849	13.31638486	-0.6588
102751	4.79545172	9.01009159	-4.21464
104321	11.5914777	13.98495988	-2.39348
105804	8.84708077	12.36214158	-3.51506
108870	7.33607302	10.49867417	-3.1626
106963	12.2487605	12.7810053	-0.53224
X00527	12.8221475	13.33632454	-0.51418
106837	8.18074339	9.019730992	-0.83899
107191	7.68366398	9.437818216	-1.75415
102804	0.29937028	4.787202394	-4.48783
103112	1.12164335	4.881818082	-3.76017
X0118XX2	3.19807332	6.333388664	-3.13532

Artifact #	C Dart (Cd)	C Arrow (Ca)	Cd - Ca
145 V	3.22487063	6.330782102	-3.10591
1/1829 1E-872	3.12770364	5.415892142	-2.28819
102084	2.97775685	6.298331218	-3.32057
102745	3.47718905	6.157317544	-2.68013
1030X2	5.25666897	7.234656788	-1.97799
103145	1.93566639	5.408595542	-3.47293
1071X0	6.52900648	8.8902542	-2.36125
102XXX	6.40542922	8.491456126	-2.08603
X	6.11046529	8.263385646	-2.15292
2/10 1E-654	1.461351	4.384037	-2.92269
2/19 1E-654	3.506879	6.436867	-2.92999
2/20 1E-655	2.052898	4.855426	-2.80253
102099	2.83606	6.748609	-3.91255
102265	4.10359	5.937196	-1.83361
106134	2.48962	5.780937	-3.29132
108923	2.04912	4.819847	-2.77073
X	2.098976	5.5442	-3.44522

An index value of 11.8mm was used (Dart > 11.8mm < Arrow)

Table F.9 Hildebrandt and King (2012).

Artifact #	Thickness	Neck	Index Value
2/33 1E-668	7.03	16.27	23.3
2/38 1E-693	7.12	15.62	22.74
2/40 1E-675	6.56	17.46	24.02
1/1813 1E-856	6.46	15.15	21.61
10X347	6.57	14.43	21
102486	7.61	15.95	23.56
X	5.39	14.21	19.6
102330	5.21	17.67	22.88
10X325	6.07	17.1	23.17
102670	5.19	17.71	22.9
107189	6.61	17.94	24.55
108590	6.37	16.21	22.58
102751	4.36	14.54	18.9
104321	5.64	18.57	24.21
105804	5.8	17.74	23.54
108870	5.3	15.28	20.58
106963	8.55	15.48	24.03
X00527	6.56	16.1	22.66
106837	6.34	11.45	17.79
107191	7.56	12.77	20.33
102804	2.74	9.95	12.69
103112	3.85	9.39	13.24

Artifact #	Thickness	Neck	Index Value
X0118XX2	2.87	10.48	13.35
145 V	2.72	10.45	13.17
1/1829 1E-872	3.99	8.65	12.64
102084	4.57	10.61	15.18
102745	3.62	9.86	13.48
1030X2	4.29	10.45	14.74
103145	4.02	9.73	13.75
1071X0	4.92	12.7	17.62
102XXX	4.07	11.99	16.06
X	4.61	11.79	16.4
2/10 1E-654	3.21	8.05	11.26
2/19 1E-654	4.64	10.41	15.05
2/20 1E-655	4.1	8.48	12.58
102099	3.14	11.67	14.81
102265	3.01	8.83	11.84
106134	2.77	9.99	12.76
108923	4.01	8.41	12.42
X	3.69	9.86	13.55

Appendix G: Projectile Point Catalogue

List of Tables

Table G.1 Projectile Point Catalogue Quantitative Attributes.

Catalogue Number	Weight (g)	Max Length (mm)	Shoulder Width (mm)	Max Thickness (mm)	Shoulder Height L (mm)	Shoulder Height R (mm)
ElNp-8/17123	4.1	27.4	21	5.95	11.4	10.1
ElNp-8/17135	5.8	49.51	23.13	4.75	10.63	10.43
ElNp-8/17144	6.3	49.58	19.19	5.69	11.6	10.08
ElNp-8/17155	5.1	34.92	21.27	5.69	10.66	10.08
ElNp-8/17136	6.3	48.28	21.11	6.45	10.74	9.84
ElNp-8/17055	6.4	42.01	22.11	7.63	11.22	10.55
ElNp-8/17156	5.2	41.83	22.39	6.17	16.8	11.81
ElNp-8/17170	4.9	41.18	20.74	6.3	13.01	12.94
ElNp-8/17079	6.5	42.32	22.09	6.18	13.05	12.85
ElNp-8/17087	4.4	39.38	20.23	5.51	10.16	10.23
ElNp-8/17054	4.3	40.82	19.38	5.53	0	10.04
ElNp-8/17074	3.7	35.05	20.09	5.77	11.17	12.62
ElNp-8/17078	4.5	36.93	21.63	6.04	10.74	11.26
ElNp-8/17080	6.8	46.85	24.41	6.72	10.9	11.64
ElNp-8/17089	3.3	32.89	17.55	5.16	9.79	10
ElNp-8/17099	6.5	44.85	23.69	5.56	11.13	10.53
ElNp-8/17104	3.4	26.42	19.7	6.17	10.38	10.6
ElNp-8/17107	7.9	54.98	21.82	5.28	10.61	7.72
ElNp-8/17108	3.4	25.93	19.36	5.17	9.93	9.78
ElNp-8/17110	4	32.39	18.11	5.85	9.51	7.97
ElNp-8/17111	4.1	34.4	22.45	5.18	10.87	10.49
ElNp-8/17113	5.7	37.37	21.21	5.54	11.71	11.78
ElNp-8/17118	9.2	55.28	25.46	6.65	10.11	14.3
ElNp-8/17120	5.3	43.33	19.99	6.09	11.89	11.79
ElNp-8/17126	6.7	46.35	20.36	6.08	11.85	10.72
ElNp-8/17131	2.7	28.19	19.43	4.72	10.42	10.23
ElNp-8/17137	7.2	45.43	22.53	5.56	11.62	10.04
ElNp-8/17147	4.5	33.44	20.88	6.46	8.79	9.82
ElNp-8/17150	2.2	21.59	18.15	5.32	9.51	8.91
ElNp-8/17151	6	41.71	23.47	5.89	10.87	10.57
ElNp-8/17159	8.5	47.4	23.7	6.91	10.88	10.61
ElNp-8/17161	10.1	60.16	25.78	6.56	12.64	13.09
ElNp-8/17174	9	54.04	19.49	6.34	9.13	10.53
ElNp-8/17176	5.1	38.88	21.52	5.39	10.8	10.12
ElNp-8/17179	2.9	26.84	17.91	5.19	9.93	9.06
ElNp-8/17186	4.1	39.16	18.61	5.22	8.94	9.25
ElNp-8/17194	6.3	36.43	24.34	6.11	11.82	12.32

Catalogue Number	Weight (g)	Max Length (mm)	Shoulder Width (mm)	Max Thickness (mm)	Shoulder Height L (mm)	Shoulder Height R (mm)
DiMv-93/14890	3.6	29.44	21.66	5.46	9.03	8.61
DiMv-93/15637	1.8	24.85	15.82	5.85	6.79	5.55
DiMv-93/10584	2.7	26.89	18.26	7.05	9.1	8.12
DiMv-93/14726	3.6	33.5	21.59	6.53	10.61	10.72
DiMv-93/13338	2.4	20.68	20.06	5.93	8.57	8.88
DiMv-93/15567	2.6	30.17	21.74	4.52	5.29	4.39
DiMv-93/16586	2.1	26.71	20.2	4.54	8.83	7.45
DiMv-93/17077	0.7	11.89	15.51	3.96	6.34	0
DiMv-93/17389	2.3	19.59	23.8	4.76	7.74	0
DiMv-93/19492	3	29.32	21.6	5.91	6.98	7.59
EiNs-4/4562	1.6	26.95	16.92	4.56	8.65	8.08
EiNs-4/5259	2.3	20.18	17.93	5.86	7.89	8.91
EiNs-4/6233	2.5	30.7	16.76	4.85	7.29	7.1
EiNs-4/6263	1.5	20.04	17.13	4.79	7.3	7.66
EiNs-4/6264	2.5	28.12	17.56	4.74	8.58	9.43
EiNs-4/6265	2.2	20.61	20.4	4.78	7.28	7.49
EiNs-4/6790	1.5	28.83	13.28	4.22	6.94	4.6
EiNs-4/5378	10.1	60.4	27.61	4	12.36	11.34
EcNl-1/5a Pl11-1	0	33.48	17.35	0	0	5.95
EcNl-1/5a Pl11-2	0	29.47	20.62	0	7.73	7.32
EcNl-1/5a Pl11-3	0	36.25	19.28	0	5.6	5.08
EcNl-1/4d Pl9-1	0	26.54	17.69	0	11.11	13.82
EcNl-1/4d Pl9-2	0	29.71	19.07	0	11.09	9.21
EcNl-1/4e Pl10-1	0	25.58	15.38	5	8.5	7.85
EcNl-1/4e Pl10-2	0	28.2	16.18	0	8.88	7.62
EcNl-1/1C-54	4	29.06	23.61	6.96	12.11	10.83
EcNl-1/1B-220	3.2	29.25	20.44	5.19	11.22	9.81
EcNl-1/1B-221	3.9	23.28	21.47	6.78	11.44	10.3
EcNl-1/1B-249	3.2	28.76	18.53	4.94	8.27	8.26
EcNl-1/4a Pl6-2	0	29.58	19.74	0	8.96	9.74
EcNl-1/4a Pl6-3	0	26.45	19.7	0	10.61	11.17
EcNl-1/4b Pl7-1	0	20.17	22.13	0	8.91	9.36
EcNl-1/4b Pl7-2	0	42.75	22.55	0	9.76	10.23
EcNl-1/4b Pl7-3	0	32.63	21.66	0	9.29	9.52
EcNm-8/2785	3.1	24.31	21.28	7.54	7.89	7.03
EcNm-8/3422	2.9	28.03	18.32	5.64	8.86	9.22
EcNm-8/2828	3.7	28.77	21.75	5.84	8.82	0
EcNm-8/3205	2.6	25.52	18.3	5.08	7.84	7.93
EcNm-8/3371	2.1	20.33	17.63	5.16	0	8.57

Catalogue Number	Weight (g)	Max Length (mm)	Shoulder Width (mm)	Max Thickness (mm)	Shoulder Height L (mm)	Shoulder Height R (mm)
EcNm-8/3468	3	28	18.95	5.91	9.31	10.38
EcNm-8/1920	3.7	24.09	21.53	6.61	0	9.26
EcNm-8/2669	3.3	29.43	19.18	7.01	6.15	8.44
EcNm-8/2494	2.6	27.46	17.75	6.82	7.14	6.6
EcNm-8/2457	2.4	28.74	17.51	5.26	0	6.89
EcNm-8/2787	3.4	31.76	19.02	8.03	9.02	9.1
EcNm-8/3207	2.9	25.59	19.11	6.04	9.03	8.45
EcNm-8/3314	3.6	30.55	18.81	5.49	6.33	0
EcNm-8/3315	2.8	30.71	17.09	5.72	11.11	9.44
EcNm-8/3817	2.6	19.26	18.49	6.69	9.43	8.48
EcNm-8/3852	1.3	18.12	15.88	3.56	7.47	8.41
EcNm-8/3841	3.2	30.29	18.31	6.61	9.6	8.45
EcNm-8/3375	6.1	50.74	21.15	8.05	6.36	6.52
FaNp-7/3-3	1.4	22.65	17.49	4.58	7.38	7.32
FaNp-7/5-6	1.6	17.41	19.13	5.16		8.47
DjPm-116/148586	0	20.17	26.26	0	9.15	0
DjPm-116/148584	0	23.76	19.43	0	11.16	9.71
DjPm-116/148560	4.1	36.61	22.1	5.87	0	10.29
DjPm-116/22289	3.6	42.02	23.88	6.45	8.47	9.06
DjPm-116/102810	0	20.84	18.69	0	8.07	0
DjPm-116/22271	3.5	29.44	22.63	8.85	9.16	8.79
DjPm-116/102849	2.8	32.16	17.82	5.31	0	10.12
DjPm-116/102848	0	29.75	19.21	0	0	7.23
DjPm-116/102804	0	48.66	19.52	0	12.17	0
DjPm-116/102851	4.7	39.29	19.23	6.57	6.75	7.11
DjPm-116/22257	2.8	32.15	19.13	4.2	10.86	7.3
DjPm-116/104544	3.4	32.23	22.44	5.32	7.96	0
DjPm-116/102844	2.1	24.23	18.93	4.68	5.79	5.9
DjPm-116/102806	2	20.4	17.88	4.56	8.43	7.71
DjPm-116/229144	4.7	44.35	19.3	6.35	8.63	10.19
DjPm-116/229182	2.2	34.98	20.42	4.4	10.54	9.87
DjPm-116/229192	1	21.3	16.34	3.41	7.97	6.62
DjPm-116/229184	0	26.44	16.44	0	9.5	0
DjPm-116/229164	3.8	38.53	20.56	5.29	7.64	10
DjPm-116/229186	1.9	23.66	15.9	5	0	8.65
DjPm-116/229163	0	29.86	23.35	0	0	9.83
DjPm-116/229145	4.1	36.58	20.5	6.41	9.15	7.59
DjPm-116/229147	3.2	34.16	20.1	4.29	9.14	0
DjPm-116/229143	0	22.07	16.04	0	7.42	8.1

Catalogue Number	Weight (g)	Max Length (mm)	Shoulder Width (mm)	Max Thickness (mm)	Shoulder Height L (mm)	Shoulder Height R (mm)
DjPm-116/229146	0	20.76	19.67	0	7.16	8.12
DjPm-116/229150	0	15.52	23.07	0	7.66	0
DjPm-116/229214	0	40.53	23.15	0	7.94	9.72
DjPm-116/229195	0	37.25	20.4	0	11.39	0
DjPm-116/229201/202	0	45.82	25.53	0	8.37	7.69
DjPm-116/229199	4.5	54.02	21.04	4.84	8.08	7.54
DjPm-116/229215	3	33.37	20.32	5.69	9.44	7.69
DjPm-116/229200	0	21.3	18.49	0	9.17	8.09
DjPm-116/102857	2.1	29.51	20.3	3.96	9.58	8.36
DjPm-116/229217	0	33.03	20.91	0	7.69	7.15
DjPm-116/229213	3.4	36.15	20	6.31	8.98	8.67
DjPm-116/229168	3.6	38.28	22.81	5.23	7.35	8.32
DjPm-116/229167	0	37.68	20.48	0	8.31	8.68
DjPm-116/229166	0	35.41	19.52	0	10.72	10.25
DlOx-5/848	4.7	42.2	19.8	5.8	12.5	12
DlOx-5/852	2.4	33.9	17.5	4.4	9.1	10.9
DlOx-5/855	1.6	26.7	16.5	4.3	9.3	9.3
DlOx-5/857	3.2	30.1	20	5.7	8.1	9.1
DlOx-5/858	3.1	39	20	4.3	11.4	11.2
DlOx-5/860	2.4	31.8	17.6	4.9	9.2	9.9
DlOx-5/861	5.4	48.2	24	4.8	11.7	12.1
DlOx-5/864	5.2	37.8	22.4	6.8	13.7	13.1
DlOx-5/865	3.3	36.4	20.6	4.9	10.5	11.7
DlOx-5/866	5	40.3	22.7	6	10.4	11.4
DlOx-5/867	2.9	30.1	17.6	5.5	9.2	8.5
DlOx-5/869	3.5	38.9	19.5	5.9	10.7	11.4
DlOx-5/870	3	33.4	17.2	5.2	7.7	8.9
DlOx-5/874	5.7	35.9	26.9	6.1	13.7	12.7
DlOx-5/876	9.5	58.7	24.6	7	9.7	10.1
DlOx-5/877	5.6	38.2	22.8	6.6	11.2	11.7
DlOx-5/879	8.4	57.5	22.9	7.2	13.1	10
DlOx-5/880	3.4	31.7	19.7	7.1	12.8	9.7
DlOx-5/881	2.4	27.1	17.2	5.5	10.2	10.3
DlOx-5/882	3.8	30.5	21.4	6.4	11.6	13.2
DlOx-5/883	1.9	23.8	16.9	5.2	10.1	9.8
DlOx-5/884	3	34.4	18.9	4.8	12.1	10.8
DlOx-5/886	4.9	25.1	24.7	7	11.9	11.7
DlOx-5/4004	2.9	32.1	20.1	5.3	8.5	8.9
DlOx-5/4237	13.7	72.7	23.6	8.6	11.3	15.8

Catalogue Number	Weight (g)	Max Length (mm)	Shoulder Width (mm)	Max Thickness (mm)	Shoulder Height L (mm)	Shoulder Height R (mm)
DIOx-5/4506	1.7	26.4	17.2	3.2	7.9	7.2
DIOx-5/4807	2.6	23.2	18.1	5.7	9.1	9.5
DIOx-5/4837	5.9	39.5	24.5	6	10.7	11.7
DIOx-5/4841	10.7	71	23	6.5	11.5	12.7
DIOx-5/4976	1.5	22.6	14.9	4.9	8.8	8.6
DIOx-5/5022	3.4	28.1	20.5	5.4	8.5	8.1
DIOx-5/5023	4.9	36.4	20.2	7	9.1	9.3
DIOx-5/5104	4.7	34.5	20.5	7.7	9.1	7.6
DIOx-5/5522	3.4	32.5	20.5	5.2	9.9	8.9
DIOx-5/5625	6.7	43.8	21.7	8.3	10.2	10.8
DIOx-5/5822	6.7	43.9	21.6	6.7	9.8	9.8
DIOx-5/5921	1.3	17.7	15.8	4.9	7.3	7.5
DIOx-5/6104	2.2	16.5	22.3	6	9.2	8.5
DIOx-5/6704	5.7	55.2	17.4	6.7	9.7	9.1
DIOx-5/7029	5.1	41.8	20.7	6.2	8.5	9.3
DIOx-5/7426	4	29	22.5	5.3	10.6	10.1
DgMr-1/4a	0	44.83	20.25	0	5.73	8.64
DgMr-1/4b	0	37.7	20.73	0	5.44	5
DgMr-1/4c	0	27.01	17.93	0	7.9	7.59
DgMr-1/4d	0	25.32	17.76	0	7.16	8

Table G.2 Projectile Point Catalogue Quantitative Attributes.

Catalogue Number	Base Width (mm)	Notch Depth L (mm)	Notch Depth R (mm)	Basal Height L (mm)	Basal Height R (mm)	Neck Width (mm)
ElNp-8/17123	19	2.5	2.5	1.9	1.9	15
ElNp-8/17135	21.45	2.81	2.46	2.58	2.27	16.96
ElNp-8/17144	18.31	2.11	2.11	2.85	2.07	15.21
ElNp-8/17155	19.5	2.81	2.19	2.62	235	15.21
ElNp-8/17136	15.78	2.08	2.16	2.15	2.5	13.75
ElNp-8/17055	22.64	1.52	1.14	5.2	5.78	19.49
ElNp-8/17156	21.01	1.65	1.51	5.93	7.91	18.26
ElNp-8/17170	19.1	2.21	2.08	4.46	4.77	15.67
ElNp-8/17079	19.22	2.07	1.92	4.77	4.84	16.76
ElNp-8/17087	19.85	2.11	2.44	3.48	4.22	15.51
ElNp-8/17054	17.94	0	2.74	2.27	4.1	15
ElNp-8/17074	17.09	0.72	2.35	6.41	4.49	15
ElNp-8/17078	21.88	2.2	3.05	3.2	3.67	16.41
ElNp-8/17080	20.23	1.88	3.19	4.1	2.11	17.43
ElNp-8/17089	17.01	1.06	1.27	2.15	1.78	14.98
ElNp-8/17099	19.06	2.8	2.71	1.793	3.02	16.32
ElNp-8/17104	19.37	2.38	1.93	2.38	2.15	15.06
ElNp-8/17107	21.54	2.87	2.47	2.64	1.47	17
ElNp-8/17108	17.86	2.1	3.26	2.87	3.4	13.33
ElNp-8/17110	16.83	1.7	1.41	2.53	2.64	14.43
ElNp-8/17111	21.67	2.19	2.55	2.98	1.92	17.27
ElNp-8/17113	18.87	2.93	2.27	2.49	2.04	14.78
ElNp-8/17118	19.29	1.25	2.99	3.18	4.83	17.38
ElNp-8/17120	20.16	2.72	2.19	1.29	4.3	15.22
ElNp-8/17126	18.68	3.1	2.08	3.51	2.68	14.65
ElNp-8/17131	16.72	2.75	2.19	2.75	2.19	13.6
ElNp-8/17137	17.96	3.28	0	1.8	0	15.07
ElNp-8/17147	18.85	2.23	2.3	2.85	0.57	15.3
ElNp-8/17150	18.02	1.48	2.04	2.45	0.94	14.58
ElNp-8/17151	22.46	2.91	2.9	2.91	1.59	17.02
ElNp-8/17159	21.9	2.77	2.75	2.31	3.64	17.08
ElNp-8/17161	21.44	3.23	3.55	2.12	3.32	16.93
ElNp-8/17174	18.6	2.13	1.96	2.95	3.13	14.96
ElNp-8/17176	19.48	2.84	2.79	3.03	2.08	14.91
ElNp-8/17179	19.53	1.81	1.27	2.98	2.15	15.55
ElNp-8/17186	17.66	2.43	2.12	0.83	3.21	14.09
ElNp-8/17194	22.98	2.84	3.21	3.36	3.32	17.71

Catalogue Number	Base Width (mm)	Notch Depth L (mm)	Notch Depth R (mm)	Basal Height L (mm)	Basal Height R (mm)	Neck Width (mm)
DiMv-93/14890	21.43	2.8	2.98	3.85	2.83	15.7
DiMv-93/15637	11.34	1.98	1.72	2.5	1.78	9.84
DiMv-93/10584	0	0	2.84	0	3.47	12.72
DiMv-93/14726	22.28	2.51	3.14	5.24	4.45	16.36
DiMv-93/13338	18.22	2.92	0	2.57	0	13.48
DiMv-93/15567	13.52	4.38	4.43	1.91	1.94	10.68
DiMv-93/16586	16.79	2.45	3.23	3.47	2.64	13.21
DiMv-93/17077	16.12	3.96	0	1.93	3.1	10.57
DiMv-93/17389	19.62	5.13	0	1.25	1.09	11.43
DiMv-93/19492	14.68	4.69	4.35	2.04	1.7	10.16
EiNs-4/4562	16.15	2.19	2.5	3.65	4	11.89
EiNs-4/5259	16.26	1.5	1.53	2.72	2.65	14.04
EiNs-4/6233	0	0	2.18	0	2.23	12.3
EiNs-4/6263	17.95	2.95	2.7	1.28	1.4	11.85
EiNs-4/6264	15.03	0	3.22	0	2.16	11.09
EiNs-4/6265	0	0	3.2	0	2.28	13.26
EiNs-4/6790	12.51	1.01	1.43	2.95	0.68	10.36
EiNs-4/5378	26.41	2.21	2.8	1.54	3.49	22.29
EcNl-1/5a Pl11-1	0	0	4.01	0	1.29	8.65
EcNl-1/5a Pl11-2	15.09	3.46	2.61	2.8	2.62	11.66
EcNl-1/5a Pl11-3	14.28	3.91	3.94	1.44	1.86	10.05
EcNl-1/4d Pl9-1	14.37	1.47	1.51	0.91	1.97	12.71
EcNl-1/4d Pl9-2	17.51	2.06	1.62	2.72	1.66	15.2
EcNl-1/4e Pl10-1	15.85	1.48	1.92	2.53	2.91	12.54
EcNl-1/4e Pl10-2	14.32	1.85	1.61	3.02	1.21	12.08
EcNl-1/1C-54	21.4	2.72	3.23	3.87	1.7	16.72
EcNl-1/1B-220	15.21	2.61	1.93	2.42	2.38	13.15
EcNl-1/1B-221	19.29	1.66	1.48	2.19	1.7	17.3
EcNl-1/1B-249	18.53	1.13	1.48	2.65	2.3	16.04
EcNl-1/4a Pl6-2	17.29	2.01	1.53	2.54	3.62	15.51
EcNl-1/4a Pl6-3	15.28	1.67	1.39	1.7	1.25	14.15
EcNl-1/4b Pl7-1	19.83	2.17	1.65	2.2	1.81	16.7
EcNl-1/4b Pl7-2	19.47	2.16	2.08	2.28	2.17	16.94
EcNl-1/4b Pl7-3	18.88	2.25	1.91	2.31	1.81	15.7
EcNm-8/2785	18.54	2.76	2.74	2.5	2.54	14.66
EcNm-8/3422	16.19	2.23	2.2	1.93	1.52	13.16
EcNm-8/2828	17.51	3.58	0	3.01	1.54	13.69
EcNm-8/3205	15.18	2.14	2.08	1.67	1.47	12.49
EcNm-8/3371	17.1	0	2.49	2.74	2.82	13.72

Catalogue Number	Base Width (mm)	Notch Depth L (mm)	Notch Depth R (mm)	Basal Height L (mm)	Basal Height R (mm)	Neck Width (mm)
EcNm-8/3468	13	1.47	1.87	3.57	3.36	12.3
EcNm-8/1920	14.66	0	3.03	0	1.88	12.66
EcNm-8/2669	15.54	2.02	1.97	1.19	1.73	13.32
EcNm-8/2494	12.58	2.82	3.08	2.13	1.43	8.81
EcNm-8/2457	12.51	0	3.3	1.85	2.96	9.22
EcNm-8/2787	13.53	2.18	2.42	1.39	0.78	11.97
EcNm-8/3207	13.05	2.14	0	1.07	0	13.11
EcNm-8/3314	0	2.04	0	1.93	0	13.04
EcNm-8/3315	15.67	2.46	1.79	2.42	3.41	12.46
EcNm-8/3817	17.83	1.28	2.28	2.42	2.79	14.8
EcNm-8/3852	15.39	2.06	1.84	3.32	3.44	12.53
EcNm-8/3841	13.86	1.04	1.39	1.07	2.54	13.36
EcNm-8/3375	0	0	4.22	0	1.15	8.9
FaNp-7/3-3	15.59	2.61	1.66	3.1	3.77	12.07
FaNp-7/5-6	19.13		3.22	1.49	2.19	12.15
DjPm-116/148586	17.61	4.51	0	4.37	4.51	13.38
DjPm-116/148584	12.77	2.88	0	2.91	0	11.45
DjPm-116/148560	18.04	0	3.31	3.2	2.47	14.34
DjPm-116/22289	17.13	3.14	3.58	3.13	1.61	14.25
DjPm-116/102810	12.05	3.29	0	1.93	0	11.71
DjPm-116/22271	17.47	2.64	2.97	2.77	2.18	14.35
DjPm-116/102849	12.43	0	2.25	3.87	3.5	10.02
DjPm-116/102848	14.73	0	2.75	2.06	1.69	13.14
DjPm-116/102804	11.8	3.64	0	1.82	0	11.95
DjPm-116/102851	13.38	2.64	2.75	1.94	2.29	10.84
DjPm-116/22257	14.4	1.55	2.3	2.68	1.47	13.69
DjPm-116/104544	17.05	3.62	0	2.53	1.58	13.87
DjPm-116/102844	14.71	3.21	2.86	1.47	0.99	11.69
DjPm-116/102806	13.88	2.37	2.42	3.02	1.94	11.71
DjPm-116/229144	12.71	3.49	3.18	2.27	1.42	10.38
DjPm-116/229182	12.95	0	3.03	0	5.78	12.41
DjPm-116/229192	12.15	1.98	2.12	3.07	2.72	10.52
DjPm-116/229184	12.55	3.36	0	2.55	2.55	9
DjPm-116/229164	14.01	3.06	3.34	2.21	2.55	12.91
DjPm-116/229186	12.15	0	2.89	3.56	4.25	11.98
DjPm-116/229163	15.25	0	4.21	2.42	3.45	12.24
DjPm-116/229145	14.98	3.89	3.69	1.39	1.26	11.07
DjPm-116/229147	14.48	3.11	0	1.9	2.08	12.24
DjPm-116/229143	13.46	3.01	3.49	2.1	2.42	8.81

Catalogue Number	Base Width (mm)	Notch Depth L (mm)	Notch Depth R (mm)	Basal Height L (mm)	Basal Height R (mm)	Neck Width (mm)
DjPm-116/229146	15.12	2.3	0	2.01	0	13.66
DjPm-116/229150	18.65	378	0	1.22	0	16.36
DjPm-116/229214	10.55	3.04	0	2.34	0	13.2
DjPm-116/229195	11.51	0	0	0	1.39	11.95
DjPm-116/229201/202	14.83	2.9	3.69	2.75	2.48	13.6
DjPm-116/229199	13.99	3	3.73	4.12	3.71	11.09
DjPm-116/229215	15.43	3.14	2.23	3.78	2.83	13.43
DjPm-116/229200	14.71	1.51	1.99	2.98	1.89	12.95
DjPm-116/102857	13.41	3.08	0	2.7	0	11.33
DjPm-116/229217	15.38	2.78	0	3.24	0	14.7
DjPm-116/229213	13.13	3.32	4.02	3.26	3.28	9.5
DjPm-116/229168	13.93	4.31	3.78	3.98	3.76	10.36
DjPm-116/229167	11.92	3.66	0	2.66	0	10.96
DjPm-116/229166	11.69	0	3.16	0	1.69	10.37
DlOx-5/848	16.1	2.2	1.6	5.3	3.3	13.4
DlOx-5/852	14.5	2	2.7	2.5	2.5	11.3
DlOx-5/855	13.1	1.2	1.3	4.2	3.2	11.9
DlOx-5/857	19.2	2.2	1.5	2.3	4.1	15.9
DlOx-5/858	16.9	2.7	2.8	0.5	2	12.6
DlOx-5/860	14.7	1.8	2	0.5	2.5	12.3
DlOx-5/861	20	3.2	3.6	5.6	2.2	15
DlOx-5/864	21.6	0	2.1	0	3.7	18.7
DlOx-5/865	19.7	3	3.2	2.5	3.5	13.9
DlOx-5/866	21.4	3.6	3.5	1.5	1.3	14.7
DlOx-5/867	17.7	2.2	2.6	2.6	0.9	12.7
DlOx-5/869	15.8	2.1	1.7	3.2	4.7	13.1
DlOx-5/870	14.7	1.1	1.1	1.3	1.3	13.6
DlOx-5/874	17.7	0	4.2	0	2.8	17.3
DlOx-5/876	22.5	2.5	2.9	2	1.4	17.6
DlOx-5/877	0	3.2	2.9	2.6	2.7	14.6
DlOx-5/879	18.2	0	3.1	0	1.9	15.3
DlOx-5/880	15	1.5	1.2	5	1.4	14.6
DlOx-5/881	17.3	2	1.7	1.9	2.5	13.4
DlOx-5/882	21.9	1.6	2.2	4.8	3.8	17.9
DlOx-5/883	18.1	1.8	2.3	1.8	1.9	13.3
DlOx-5/884	1.8	1.4	1.9	3.4	4.3	14.2
DlOx-5/886	18.9	2.3	1.9	3.7	3.2	17.2
DlOx-5/4004	17.3	2.4	1.5	3.3	2.9	14.5
DlOx-5/4237	22.9	2.9	2.4	5.5	1.5	17.5

Catalogue Number	Base Width (mm)	Notch Depth L (mm)	Notch Depth R (mm)	Basal Height L (mm)	Basal Height R (mm)	Neck Width (mm)
DlOx-5/4506	12	1.9	2	1.9	1.7	10.3
DlOx-5/4807	19.5	2.2	1.9	1.8	2	14.4
DlOx-5/4837	19.3	1	3	3.1	2.8	17.1
DlOx-5/4841	20.2	2.8	1.9	3.5	3.8	16.7
DlOx-5/4976	15.3	1.5	3.2	3.2	1.7	9.7
DlOx-5/5022	18.8	1.4	1.5	1.9	1.2	17.4
DlOx-5/5023	19	2.2	2.1	1.8	3.1	15.2
DlOx-5/5104	19.2	1.3	1.7	1.5	1	16.6
DlOx-5/5522	18.8	1.4	1.5	1.9	1.2	17.4
DlOx-5/5625	17.1	1.9	2.7	1.3	2.3	14.7
DlOx-5/5822	17.1	2.2	1.6	1.8	4	15.4
DlOx-5/5921	15.7	0.6	0.5	2.3	3.4	14.4
DlOx-5/6104	20.7	2.4	3.7	1.9	1.2	15.2
DlOx-5/6704	16.7	1.7	2.1	3.1	2.8	13.4
DlOx-5/7029	16.6	2.3	1.6	2.5	0.8	13.32
DlOx-5/7426	21.2	2.4	2.2	3.9	2.1	17
DgMr-1/4a	15.6	6.87	0	0.72	1.08	6.1
DgMr-1/4b	0	5.21	0	1.29	0	6.04
DgMr-1/4c	11.32	3.49	4.01	1.81	1.89	7.41
DgMr-1/4d	0	2.95	0	1.37	0	8.28

Table G.3 Projectile Point Catalogue Qualitative Attributes.

Catalogue Number	Material	Longitudinal Cross-Section	Transverse Cross-Section
EINp-8/17123	Knife River Flint	Plano-Convex	Biconvex
EINp-8/17135	Knife River Flint	Biplano	Biconvex
EINp-8/17144	Knife River Flint	Concave / Convex	Biconvex
EINp-8/17155	Knife River Flint	Concave / Convex	Plano-Convex
EINp-8/17136	Knife River Flint	Plano-Convex	Biconvex
EINp-8/17055	Knife River Flint	Biconvex	Asym Biconvex
EINp-8/17156	Knife River Flint	Biplano	Plano-Convex
EINp-8/17170	Knife River Flint	Plano-Convex	Biconvex
EINp-8/17079	Knife River Flint	Biplano	Biconvex
EINp-8/17087	Knife River Flint	Plano-Convex	Biconvex
EINp-8/17054	Knife River Flint	Biplano	Plano-Triangular
EINp-8/17074	Knife River Flint	Plano-Convex	Biconvex
EINp-8/17078	Knife River Flint	Biconvex	Biconvex
EINp-8/17080	Knife River Flint	Concave / Convex	Biconvex
EINp-8/17089	Knife River Flint	Concave / Convex	Biconvex
EINp-8/17099	Knife River Flint	Biconvex	Biconvex
EINp-8/17104	Knife River Flint	Plano-Convex	Biconvex
EINp-8/17107	Knife River Flint	Plano-Convex	Biconvex
EINp-8/17108	Knife River Flint	Plano-Convex	Biconvex

Catalogue Number	Material	Longitudinal Cross-Section	Transverse Cross-Section
ElNp-8/17110	Knife River Flint	Biconvex	Biconvex
ElNp-8/17111	Knife River Flint	Biconvex	Biconvex
ElNp-8/17113	Knife River Flint	Biconvex	Biconvex
ElNp-8/17118	Knife River Flint	Biconvex	Biconvex
ElNp-8/17120	Knife River Flint	Concave / Convex	Biconvex
ElNp-8/17126	Knife River Flint	Concave / Convex	Biconvex
ElNp-8/17131	Knife River Flint	Concave / Convex	Biconvex
ElNp-8/17137	Knife River Flint	Biconvex	Biconvex
ElNp-8/17147	Knife River Flint	Biconvex	Biconvex
ElNp-8/17150	Knife River Flint	Biconvex	Biconvex
ElNp-8/17151	Knife River Flint	Biconvex	Biconvex
ElNp-8/17159	Knife River Flint	Biconvex	Biconvex
ElNp-8/17161	Knife River Flint	Concave / Convex	Biconvex
ElNp-8/17174	Knife River Flint	Biconvex	Biconvex
ElNp-8/17176	Knife River Flint	Biconvex	Biconvex
ElNp-8/17179	Knife River Flint	Biconvex	Biconvex
ElNp-8/17186	Knife River Flint	Plano-Convex	Biconvex
ElNp-8/17194	Knife River Flint	Plano-Convex	Biconvex
DiMv-93/14890	Knife River Flint	Biconvex	Biconvex
DiMv-93/15637	Chalcedony	Biconvex	Biconvex

Catalogue Number	Material	Longitudinal Cross-Section	Transverse Cross-Section
DiMv-93/10584	Fused Shale	Biconvex	Biconvex
DiMv-93/14726	Unknown Chert (Grey Banded)	Biconvex	Biconvex
DiMv-93/13338	Swan River Chert (Heat Treated)	Plano-Convex	Biconvex
DiMv-93/15567	Knife River Flint	Biconvex	Biconvex
DiMv-93/16586	Knife River Flint	Concave / Convex	Biconvex
DiMv-93/17077	Fused Shale	N/A	N/A
DiMv-93/17389	Knife River Flint	Biconvex	Biconvex
DiMv-93/19492	Knife River Flint	Biconvex	Biconvex
EiNs-4/4562	Jasper	Plano-Convex	Biconvex
EiNs-4/5259	Silicified Peat	Biconvex	Biconvex
EiNs-4/6233	Knife River Flint	Biconvex	Biconvex
EiNs-4/6263	Knife River Flint	Biconvex	Biconvex
EiNs-4/6264	Knife River Flint	Plano-Convex	Biconvex
EiNs-4/6265	Knife River Flint	Concave / Convex	Biconvex
EiNs-4/6790	Knife River Flint	Plano-Convex	Biconvex
EiNs-4/5378	Knife River Flint	Unknown	Unknown
EcNl-1/5a Pl11-1	Jasper	Unknown	Biconvex
EcNl-1/5a Pl11-2	Silicified Peat	Unknown	Unknown
EcNl-1/5a Pl11-3	Moss Agate	Unknown	Biconvex
EcNl-1/4d Pl9-1	Swan River Chert	Unknown	Unknown

Catalogue Number	Material	Longitudinal Cross-Section	Transverse Cross-Section
EcNl-1/4d Pl9-2	Silicified Peat	Unknown	Unknown
EcNl-1/4e Pl10-1	Unknown	Unknown	Unknown
EcNl-1/4e Pl10-2	Unknown	Plano-Convex	Unknown
EcNl-1/1C-54	Swan River Chert (Heat Treated)	Biconvex	Biconvex
EcNl-1/1B-220	Knife River Flint	Plano-Convex	Biconvex
EcNl-1/1B-221	Swan River Chert (Heat Treated)	Biconvex	Biconvex
EcNl-1/1B-249	Silicified Peat	Biconvex	Biconvex
EcNl-1/4a Pl6-2	Unknown	Unknown	Unknown
EcNl-1/4a Pl6-3	Unknown	Unknown	Unknown
EcNl-1/4b Pl7-1	Unknown	Unknown	Unknown
EcNl-1/4b Pl7-2	Unknown	Unknown	Unknown
EcNl-1/4b Pl7-3	Unknown	Unknown	Unknown
EcNm-8/2785	Silicified Peat	Biconvex	Biconvex
EcNm-8/3422	Silicified Peat	Biconvex	Biconvex
EcNm-8/2828	Swan River Chert (Heat Treated)	Biconvex	Biconvex
EcNm-8/3205	Swan River Chert (Heat Treated)	Concave / Convex	Biconvex
EcNm-8/3371	Swan River Chert (Heat Treated)	Biconvex	Biconvex
EcNm-8/3468	Unknown Chert (Yellow)	Plano-Convex	Plano-Convex
EcNm-8/1920	Swan River Chert (Heat Treated)	Plano-Convex	Plano-Convex
EcNm-8/2669	Silicified Peat	Biconvex	Biconvex

Catalogue Number	Material	Longitudinal Cross-Section	Transverse Cross-Section
EcNm-8/2494	Chalcedony	Biconvex	Biconvex
EcNm-8/2457	Silicified Peat	Concave / Convex	Biconvex
EcNm-8/2787	Quartzite	Biconvex	Concave / Convex
EcNm-8/3207	Silicified Peat	Concave / Convex	Biconvex
EcNm-8/3314	Swan River Chert (Heat Treated)	Biconvex	Biconvex
EcNm-8/3315	Swan River Chert (Heat Treated)	Biconvex	Biconvex
EcNm-8/3817	Swan River Chert (Heat Treated)	Plano-Convex	Plano-Convex
EcNm-8/3852	Knife River Flint	Plano-Convex	Plano-Convex
EcNm-8/3841	Swan River Chert (Heat Treated)	Plano-Convex	Biconvex
EcNm-8/3375	Silicified Peat	Biconvex	Biconvex
FaNp-7/3-3	Unknown Chert (Yellow)	Biconvex	Asym Biconvex
FaNp-7/5-6	Swan River Chert (Heat Treated)	Biconvex	Bi-triangular
DjPm-116/148586	Unknown	Unknown	Unknown
DjPm-116/148584	Unknown	Unknown	Unknown
DjPm-116/148560	Chalcedony	Unknown	Unknown
DjPm-116/22289	Argillite	Unknown	Unknown
DjPm-116/102810	Unknown	Unknown	Unknown
DjPm-116/22271	Chert	Unknown	Unknown
DjPm-116/102849	Chert	Unknown	Unknown
DjPm-116/102848	Unknown	Unknown	Unknown

Catalogue Number	Material	Longitudinal Cross-Section	Transverse Cross-Section
DjPm-116/102804	Unknown	Unknown	Unknown
DjPm-116/102851	Avon Chert	Unknown	Unknown
DjPm-116/22257	Swan River Chert (Heat Treated)	Unknown	Unknown
DjPm-116/104544	Swan River Chert (Heat Treated)	Unknown	Unknown
DjPm-116/102844	Chert	Unknown	Unknown
DjPm-116/102806	Swan River Chert (Heat Treated)	Unknown	Unknown
DjPm-116/229144	Chert	Unknown	Unknown
DjPm-116/229182	Argillite	Unknown	Unknown
DjPm-116/229192	Chert	Unknown	Unknown
DjPm-116/229184	Unknown	Unknown	Unknown
DjPm-116/229164	Swan River Chert (Heat Treated)	Unknown	Unknown
DjPm-116/229186	Swan River Chert (Heat Treated)	Unknown	Unknown
DjPm-116/229163	Unknown	Unknown	Unknown
DjPm-116/229145	Siltstone	Unknown	Unknown
DjPm-116/229147	Siltstone	Unknown	Unknown
DjPm-116/229143	Unknown	Unknown	Unknown
DjPm-116/229146	Unknown	Unknown	Unknown
DjPm-116/229150	Unknown	Unknown	Unknown
DjPm-116/229214	Unknown	Unknown	Unknown
DjPm-116/229195	Argillite	Unknown	Unknown

Catalogue Number	Material	Longitudinal Cross-Section	Transverse Cross-Section
DjPm-116/229201/202	Unknown	Unknown	Unknown
DjPm-116/229199	Chert	Unknown	Unknown
DjPm-116/229215	Chert	Unknown	Unknown
DjPm-116/229200	Swan River Chert (Heat Treated)	Unknown	Unknown
DjPm-116/102857	Chert	Unknown	Unknown
DjPm-116/229217	Unknown	Unknown	Unknown
DjPm-116/229213	Chert	Unknown	Unknown
DjPm-116/229168	Chert	Unknown	Unknown
DjPm-116/229167	Unknown	Unknown	Unknown
DjPm-116/229166	Unknown	Unknown	Unknown
DlOx-5/848	Knife River Flint	Plano-Convex	Plano-Convex
DlOx-5/852	Knife River Flint	Concave / Convex	Plano-Triangular
DlOx-5/855	Silicified Mudstone	Concave / Convex	Plano-Convex
DlOx-5/857	Knife River Flint	Biconvex	Plano-Convex
DlOx-5/858	Knife River Flint	Concave / Convex	Biconvex
DlOx-5/860	Knife River Flint	Biconvex	Biconvex
DlOx-5/861	Knife River Flint	Biconvex	Biconvex
DlOx-5/864	Knife River Flint	Plano-Convex	Plano-Convex
DlOx-5/865	Knife River Flint	Plano-Convex	Plano-Convex
DlOx-5/866	Knife River Flint	Plano-Convex	Plano-Convex

Catalogue Number	Material	Longitudinal Cross-Section	Transverse Cross-Section
DlOx-5/867	Knife River Flint	Plano-Convex	Plano-Triangular
DlOx-5/869	Knife River Flint	Biconvex	Biconvex
DlOx-5/870	Knife River Flint	Plano-Convex	Plano-Convex
DlOx-5/874	Knife River Flint	Unknown	Biconvex
DlOx-5/876	Knife River Flint	Biconvex	Biconvex
DlOx-5/877	Knife River Flint	Plano-Triangular	Biconvex
DlOx-5/879	Knife River Flint	Biconvex	Biconvex
DlOx-5/880	Fused Shale	Biconvex	Plano-Convex
DlOx-5/881	Knife River Flint	Plano-Convex	Plano-Convex
DlOx-5/882	Knife River Flint	Biconvex	Biconvex
DlOx-5/883	Knife River Flint	Plano-Convex	Plano-Convex
DlOx-5/884	Knife River Flint	Plano-Convex	Biconvex
DlOx-5/886	Knife River Flint	Unknown	Biconvex
DlOx-5/4004	Knife River Flint	Plano-Convex	Plano-Triangular
DlOx-5/4237	Knife River Flint	Plano-Convex	Biconvex
DlOx-5/4506	Silicified Mudstone	Concave / Convex	Plano-Convex
DlOx-5/4807	Knife River Flint	Unknown	Biconvex
DlOx-5/4837	Knife River Flint	Concave / Convex	Biconvex
DlOx-5/4841	Knife River Flint	Concave / Convex	Biconvex
DlOx-5/4976	Knife River Flint	Concave / Convex	Biconvex

Catalogue Number	Material	Longitudinal Cross-Section	Transverse Cross-Section
DlOx-5/5022	Knife River Flint	Biconvex	Plano-Triangular
DlOx-5/5023	Knife River Flint	Biconvex	Biconvex
DlOx-5/5104	Knife River Flint	Plano-Convex	Biconvex
DlOx-5/5522	Knife River Flint	Biconvex	Biconvex
DlOx-5/5625	Knife River Flint	Biconvex	Biconvex
DlOx-5/5822	Knife River Flint	Biconvex	Biconvex
DlOx-5/5921	Siltstone	Biconvex	Plano-Convex
DlOx-5/6104	Knife River Flint	Biconvex	Biconvex
DlOx-5/6704	Knife River Flint	Concave / Convex	Plano-Convex
DlOx-5/7029	Knife River Flint	Biconvex	Biconvex
DlOx-5/7426	Knife River Flint	Plano-Convex	Plano-Convex
DgMr-1/4a	Knife River Flint	Biconvex	Biconvex
DgMr-1/4b	Knife River Flint	Biconvex	Biconvex
DgMr-1/4c	White Chalcedony	Biconvex	Biconvex
DgMr-1/4d	Fused Shale	Biconvex	Biconvex

Appendix H: Walter Felt Projectile Points

List of Figures

List of Tables

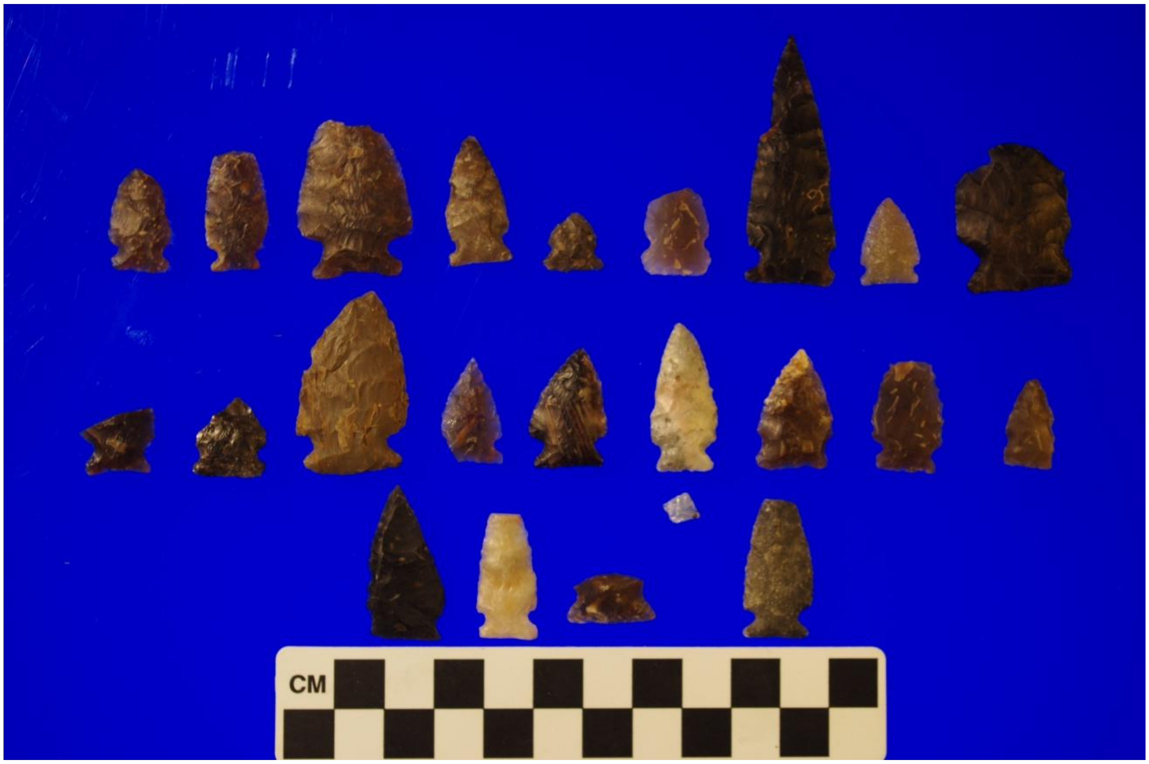


Figure H.1 Walter Felt Level 10 Projectile Points.

Left to Right Top Row: 203, 1065, 1239, 1503, 1509, 1517, 1569, 1753, 1877
Left to Right Middle Row: 1910, 1946, 2129, 2220, 2255, 2264, 2391, 2425, 2441
Left to Right Bottom Row: 2595, 2701, 3126, 3231, 3452

Table H.1 Select Projectile Points Walter Felt Level 10.

Catalogue Number	Level	Weight (g)	Max Thickness (mm)	Material	Longitudinal Cross-Section	Transverse Cross-Section
EcNm-8/203	10	1	3.61	Knife River Flint	Biconvex	Biconvex
EcNm-8/1065	10	1.1	3.34	Knife River Flint	Biconvex	Biconvex
EcNm-8/1239	10	3.9	4.56	Knife River Flint	Biconvex	Biconvex
EcNm-8/1503	10	1.2	3.59	Silicified Peat	Biconvex	Biconvex
EcNm-8/1509	10	0.3	2.99	Silicified Peat	Biconvex	Biconvex
EcNm-8/1517	10	0.9	3.19	Knife River Flint	Plano-Convex	Plano-Convex
Ecnm-8/1569	10	4.4	5.22	Knife River Flint	Biconvex	Biconvex
EcNm-8/1753	10	0.6	3.21	Quartzite	biconvex	Biconvex
EcNm-8/1877	10	4.7	6.18	Silicified Peat	Biconvex	Biconvex
EcNm-8/1910	10	0.6	3.61	Knife River Flint	Biconvex	Biconvex
EcNm-8/2129	10	4.5	5.01	Silicified Peat	Biconvex	Biconvex
EcNm-8/2220	10	0.7	2.84	Knife River Flint	Biconvex	Biconvex

Catalogue Number	Level	Weight (g)	Max Thickness (mm)	Material	Longitudinal Cross-Section	Transverse Cross-Section
EcNm-8/2255	10	1.3	3.47	Silicified Wood	Plano-Convex	Plano-Convex
EcNm-8/2264	10	1.8	4.61	SRC (Heat Treated)	Biconvex	Biconvex
EcNm-8/2391	10	1.7	4.48	Knife River Flint	Biconvex	Biconvex
EcNm-8/2425	10	1.2	2.74	Knife River Flint	Concave / Convex	Concave / Convex
EcNm-8/2441	10	0.6	3.24	Knife River Flint	Biconvex	Biconvex
EcNm-8/2595	10	1.8	3.94	Knife River Flint	Concave / Convex	Concave / Convex
EcNm-8/2701	10	1.3	4.14	SRC (Heat Treated)	Biconvex	Biconvex
EcNm-8/3452	10	1.8	4.19	Quartzite	Biconvex	Biconvex

Figure H.2 Walter Felt Level 13a Projectile Points.

Left to Right Top Row: 3247, 3259, 3268, 3275, 3276, 3296, 3297
Left to Right Bottom Row: 3305, 3307, 3308, 3401, 3427, 3466, 3547

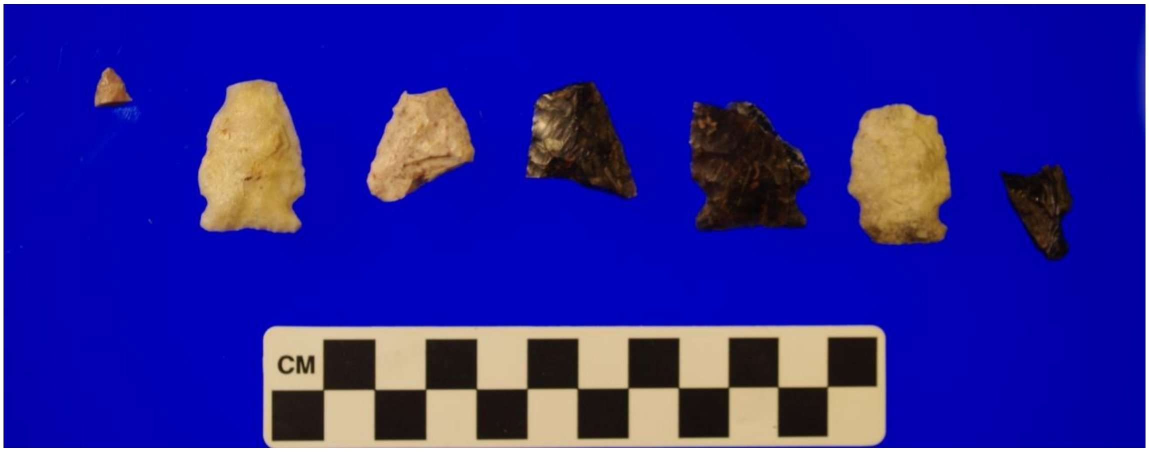


Figure H.3 Walter Felt Level 13a Projectile Points.

Left to Right: 3644, 3666, 3805, 3806, 3807/3824, 3816, 3465

Table H.2 Select Projectile Points Walter Felt Level 13a.

Catalogue Number	Level	Weight (g)	Max Thickness (mm)	Material	Longitudinal Cross-Section	Transverse Cross-Section
EcNm-8/3249	13a	2.1	5.69	Knife River Flint	Biconvex	Biconvex
EcNm-8/3259	13a	2	5.22	Silicified Wood	Biconvex	Biconvex
EcNm-8/3276	13a	3.4	5.34	Silicified Peat	Biconvex	Biconvex
EcNm-8/3296	13a	4.3	7.38	SRC (Heat Treated)	Plano-Convex	Biconvex
EcNm-8/3401	13a	2.2	5.51	Silicified Peat	Concave / Convex	Concave / Convex
EcNm-8/3305	13a	0.8	3.57	Silicified Wood	Plano-Convex	Plano-Convex
EcNm-8/3547	13a	2.8	5.42	SRC (Heat Treated)	Biconvex	Biconvex
EcNm-8/3666	13a	4.1	6.06	SRC (Heat Treated)	Plano-Convex	Plano-Convex
EcNm-8/3807&3824	13a	4	5.84	Knife River Flint	Biconvex	Biconvex
EcNm-8/3816	13a	4.4	6.88	SRC	Plano-Convex	Biconvex

Figure H.4 Walter Felt Level 13c Projectile Points.

Left to Right Top Row: 2784, 2786, 2828, 3206, 3295
Left to Right Bottom Row: 3371, 3422, 3468, 3480

Table H.3 Select Projectile Points Walter Felt Level 13c.

Catalogue Number	Level	Weight (g)	Max Thickness (mm)	Material	Longitudinal Cross-Section	Transverse Cross-Section
EcNm-8/2785	13c	3.1	7.54	Silicified Peat	Biconvex	Biconvex
EcNm-8/2828	13c	3.7	5.84	SRC (Heat Treated)	Biconvex	Biconvex
EcNm-8/3206	13c-15a	2.6	5.08	SRC (Heat Treated)	Concave / Convex	Biconvex
EcNm-8/3371	13c	2.1	5.16	SRC (Heat Treated)	Biconvex	Biconvex
EcNm-8/3422	13c	2.9	5.64	Silicified Peat	Biconvex	Biconvex
EcNm-8/3468	13c	3	5.91	Unknown Chert	Plano-Convex	Plano-Convex

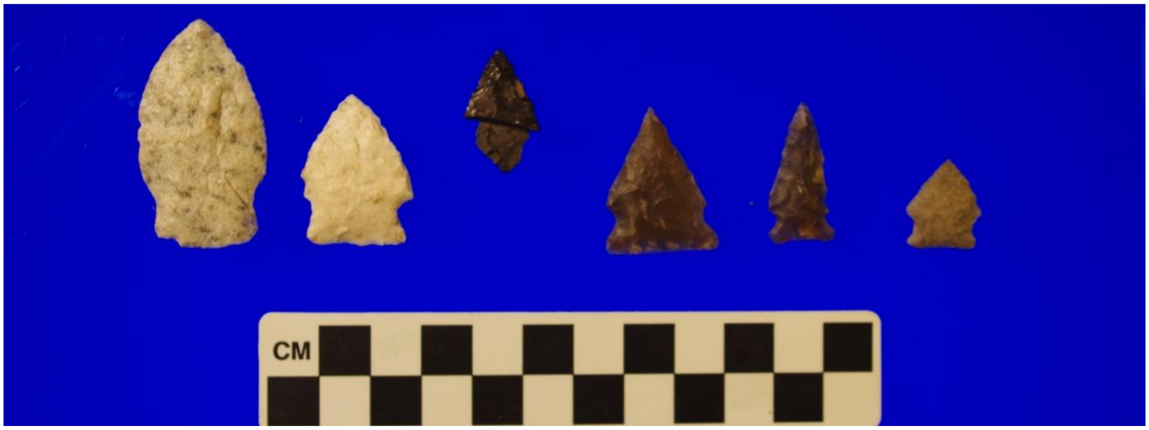


Figure H.5 Unassigned Walter Felt Level 13 Projectile Points.

Left to Right: 611, 2743, 3304, 4092, 4099, 4305

Table H.4 Select Projectile Points Unassigned Walter Felt Level 13.

Catalogue Number	Level	Weight (g)	Max Thickness (mm)	Material	Longitudinal Cross-Section	Transverse Cross-Section
EcNm-8/611	7-13	7.8	7.19	SRC	Biconvex	Biconvex
EcNm-8/2743	13	3.9	6.34	SRC	Biconvex	Biconvex
EcNm-8/4092	13	3.1	5.26	Knife River Flint	Biconvex	Biconvex
EcNm-8/4099	13	1.2	3.65	Knife River Flint	Plano-Convex	Plano-Convex
EcNm-8/4305	13	1.1	4.2	SRC (Heat Treated)	Biconvex	Biconvex

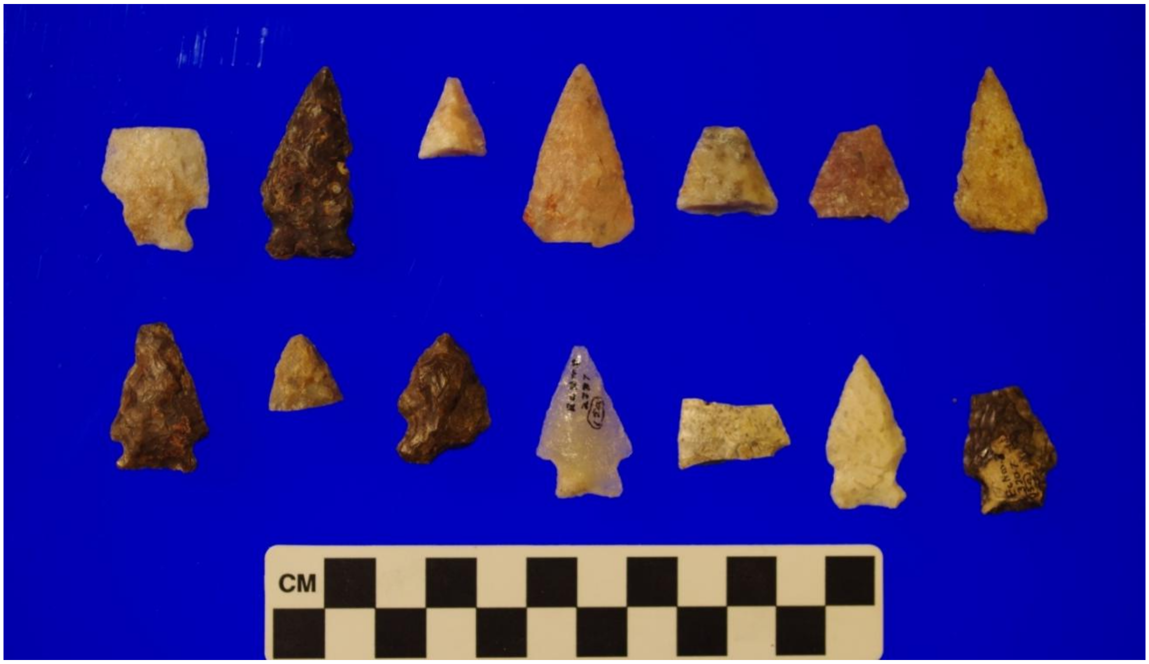


Figure H.6 Walter Felt Level 15a Projectile Points.

Left to Right Top Row: 1920, 2201, 2224, 2304, 2305, 2312, 2664
Left to Right Bottom Row: 2669, 2704, 2705, 2787, 2829, 3315, 3207

Figure H.7 Walter Felt Level 15a Projectile Points.

Left to Right Top Row: 3314, 3315, 3448, 3656, 3817, 3832
Left to Right Bottom Row: 3841, 3842, 3844, 4110, 4273

Table H.5 Select Projectile Points Walter Felt Level 15a.

Catalogue Number	Level	Weight (g)	Max Thickness (mm)	Material	Longitudinal Cross-Section	Transverse Cross-Section
EcNm-8/1920	15a	3.7	6.61	SRC (Heat Treated)	Plano-Convex	Plano-Convex
EcNm-8/2669	15a	3.3	7.01	Silicified Peat	Biconvex	Biconvex
EcNm-8/2787	15a	3.4	8.03	Quartzite	Biconvex	Concave / Convex
EcNm-8/3207	15a	2.9	6.04	Silicified Peat	Concave / Convex	Biconvex
EcNm-8/3314	15a	3.6	5.49	SRC (Heat Treated)	Biconvex	Biconvex
EcNm-8/3315	15a	2.8	5.72	SRC (Heat Treated)	Biconvex	Biconvex
EcNm-8/3817	15a	2.6	6.69	SRC (Heat Treated)	Plano-Convex	Plano-Convex
EcNm-8/3852	15a	1.3	3.56	Knife River Flint	Plano-Convex	Plano-Convex
EcNm-8/3841	15a	3.2	6.61	SRC (Heat Treated)	Plano-Convex	Biconvex
EcNm-8/3842	15a	5.6	8.24	SRC (Heat Treated)	Plano-Convex	Plano-Convex

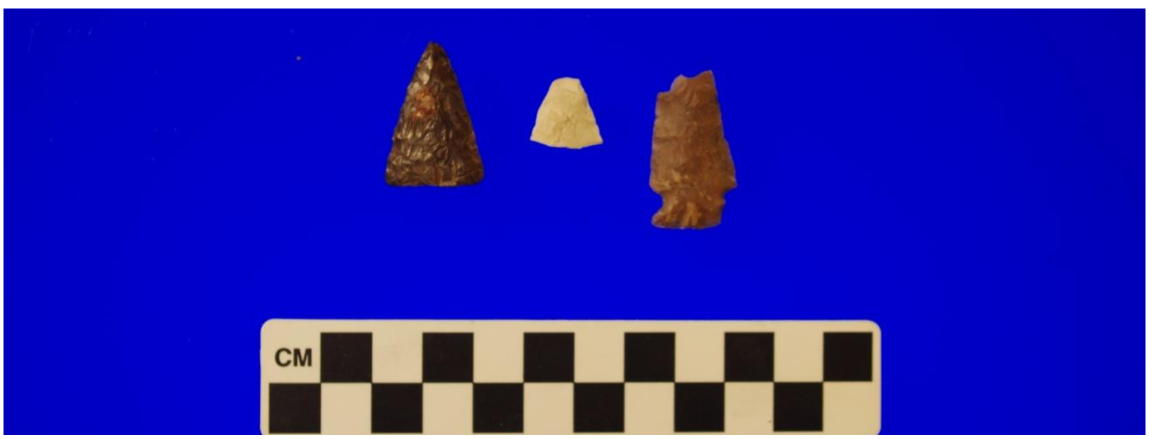


Figure H.8 Walter Felt Level 15b Projectile Points.

Left to Right: 2024, 2202, 2270

Table H.6 Select Projectile Points Walter Felt Level 15b.

Catalogue Number	Level	Weight (g)	Max Thickness (mm)	Material	Longitudinal Cross-Section	Transverse Cross-Section
EcNm-8/3846	15b	2.9	5.01	Red Chalcedony	Biconvex	Biconvex

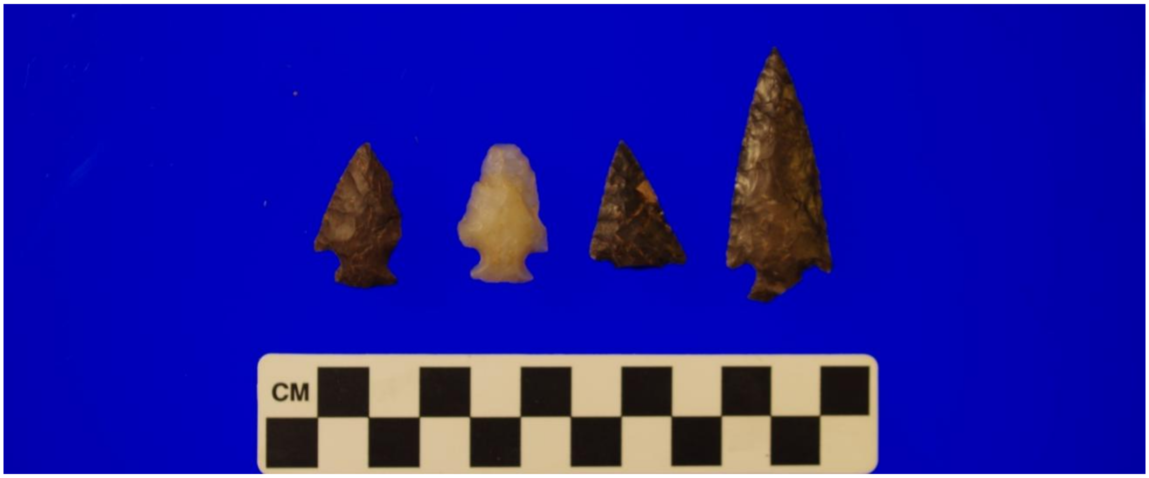


Figure H.9 Walter Felt Level 15d Projectile Points.

Left to Right: 2457, 2494, 2577, 3375

Table H.7 Select Projectile Points Walter Felt Level 15d.

Catalogue Number	Level	Weight (g)	Max Thickness (mm)	Material	Longitudinal Cross-Section	Transverse Cross-Section
EcNm-8/2457	15d	2.4	5.26	Silicified Peat	Concave / Convex	Biconvex
EcNm-8/2494	15d	2.6	6.82	Chalcedony	Biconvex	Biconvex
EcNm-8/3375	15d	6.1	8.05	Silicified Peat	Biconvex	Biconvex

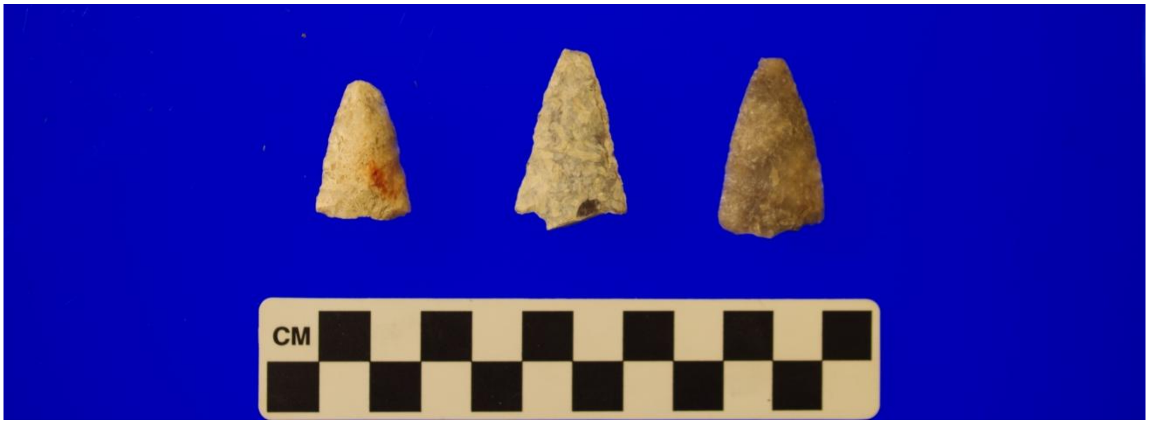


Figure H.10 Unassigned Walter Felt Level 15 Projectile Points.